WARNING:
FAULTY REPORTING OF US COAL RESERVES

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Accelerating the transition from fossil fuels to a clean energy economy

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WARNING:
FAULTY REPORTING OF US COAL RESERVES

Why Reports of a "200 Year Supply" of Cheap US Coal Are Faulty

and

The Imperative of Repowering the United States

A Report by Clean Energy Action
Leslie Glustrom, Director of Research and Policy

October 2013

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Comments and corrections to Leslie Glustrom lglustrom (at) cleanenergyaction.org or 303-245-8637.

Other Coal Reports, Presentations and Testimony Authored or Co-Authored by Leslie Glustrom

2012

Co-author of "Trends in U.S. Coal Costs: 2004-2011"
Available for free download from
http://cleanenergyaction.files.wordpress.com/2011/06/u-s-coal-costs-2004-2011.pdf

2011

Co-author on the Harvard report "Full Cost Accounting of the Life Cycle of Coal" Published in the Annals of the New York Academy of Sciences. Available for purchase here:
http://onlinelibrary.wiley.com/doi/10.1111/j.1749-6632.2010.05890.x/full

2009

Sole author of "Coal Cheap and Abundant—Or Is It? Why Americans Should Stop Assuming that The U.S. has a 200 Year Supply of Coal." Includes over 200 hyperlinked references, available for free download here:
http://cleanenergyaction.files.wordpress.com/2011/10/coal_supply_constraints_cea_0212091.pdf

Leslie Glustrom has spoken around the country regarding the issue of US coal supplies. Below are a few examples of these talks.

- **2012—Midwest Renewable Energy Association in Wisconsin.**
  http://www.youtube.com/watch?v=7UxV-aix7uc&list=PLjfcXJZZULlSwJgUi6V1OkHsQcCo-6m2t&index=3
- **2012—Colorado Interfaith Power and Light**
  http://www.youtube.com/watch?v=f4h35zRp4t4
- **2009—Next Agenda Clean Energy Challenge, San Francisco, California**
  http://www.youtube.com/watch?v=E8ttzkGLC1Y
- **2009—Michigan Futures Conference**
  http://www.youtube.com/watch?v=t0y3KPmM22g

For copies of testimony submitted to the Colorado Public Utilities Commission on coal cost and supply issues, contact the author at 303-245-8637 or lglustrom (at) cleanenergyaction.org

Note from the Author to EIA Employees

The author recognizes and appreciates the tremendous work of the many fine employees at the Energy Information Administration (EIA). While this report questions the EIA's reporting of US coal reserves, the author also recognizes that this report—and many others—could not be written without the dedicated work of the many women and men who collect data on US energy supplies and usage.

It appears that the EIA's currently reported Estimated Recoverable Reserves for US coal is a number that originated several decades ago and which the current employees of EIA "inherited." In addition, the EIA has never been adequately funded to conduct the studies that would have allowed the number to be updated.

At this point in time, it is the author's belief that the EIA should not attempt to determine US coal reserves given the difficulty of projecting this number—a number that is dependent on the interplay of many complicated variables that are each in themselves difficult to project.

Alternatively, if the EIA adjusts its reporting of "ERR" from Estimated Recoverable "Reserves" to Estimated Recoverable Resources, then it will allow the United States to begin a more thoughtful discussion of our economically accessible coal supplies, to take a hard look at what is happening currently in the coal industry and to monitor new developments carefully to provide a more accurate foundation for planning to ensure the stability of the US electrical grid in the post-coal era.

It is essential that the US have a realistic understanding of its coal supplies, but nothing in this report is meant to challenge the competence or dedication of the hard-working employees of the EIA. The author is indebted to them for their on-going and heroic efforts to manage and publish large amounts of data regarding energy supplies and use in the United States.

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Frank Zaski, Michigan Energy and Coal Analyst

Thanks to Mary Pettigrew of Ampersand Graphic Design for final formatting and to Cathy Conery for final proofreading.

All errors are the responsibility of the primary author, Leslie Glustrom.

Forming a Realistic Time Frame for Repowering the US

It is the author's observation that geologists tend to assume available money is "infinite," while financial analysts tend to assume available coal is "infinite." Neither of these is true and it is only by combining thoughtful estimates of available coal and available money that our country can come to a realistic estimate of the amount of US coal that can be mined at a profit to power our country.

One goal of this report is to inspire geologists to study coal company financials and financial analysts to study coal geology reports and then to combine their knowledge, so that the US can gain a realistic assessment of accessible coal supplies and a proper time frame for repowering our country for the 21st century.

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Warning: Faulty Reporting of US Coal Reserves

RECOMMENDATIONS

1. **EIA** should begin reporting what it has termed "Estimated Recoverable Reserves" as "Estimated Recoverable Resources."
2. **Utilities** should avoid long term investments in coal—on price and supply issues alone—independent of concerns about climate change or other emission issues.
3. **Utility Regulators** should avoid approving long term investments in coal—on price and supply issues alone—independent of concerns about climate change or other emission issues.
4. **Elected officials** should begin a careful examination of coal cost and supply issues in their state.
5. **Investors** should take a hard look at the geology of US coal and at the finances of US coal companies before making large investments in coal assets.
6. **Economic leaders** should advocate for a rapid repowering of the United States—independent of their views on climate change or other environmental and health issues.
7. **Energy consultants** should avoid making projections for the 21st century based on trends from the 20th century. Coal is non-renewable and the past will not describe the future.
8. **Academics** should begin taking a hard look at coal cost and supply issues and begin publishing analyses that address the proper time frame for getting the US repowered.
9. **Utility customers** should begin asking hard questions about coal cost and supply issues as they relate to their electricity bills and the current electricity providers in their state.
10. **Everyone** should discuss the need for repowering the United States for the 21st century.

Key "Take Home"

The belief that the US has a "200 year" supply of coal is based on the faulty reporting by the EIA of US coal deposits as "reserves." Most US coal is buried too deeply to be mined at a profit and should not be categorized as reserves, but rather as "**resources**." All decision makers should begin taking a hard look at coal cost and supply issues considering both geology and finance and begin thinking about scenarios that require moving the US beyond coal in significantly less than 20 years. Since coal is non-renewable, analyses should be based on recent trends—not those of the 20th century, which are not likely to be repeated.

Acronyms

BLM	Bureau of Land Management in the US Department of the Interior
BTU	British Thermal Units—a measure of heat content.
EIA	Energy Information Administration in the US Department of Energy
EFH	Energy Future Holdings
EIS	Environmental Impact Statement
EPA	Environmental Protection Agency (US)
EPS	Earnings Per Share
ERR	Estimated Recoverable Reserves (as reported by the US EIA)
Gt	Gigatons (billion tons)
IGCC	Integrated Gasification and Combined Cycle (often referred to as "clean coal.")
Mt	Megatons (million tons)
Metric Tons (or Tonnes)	1,000 kilograms or 2,205 pounds
MMBTU	Million BTU or British Thermal Units, a measure of heat content
NCRA	National Coal Resource Assessment
ROE	Return on Equity
ROI	Return on Investment
Tons	English ton (2000 pounds)
TXU	Texas Utilities
US	United States
USGS	United States Geological Survey in the US Department of the Interior

EXECUTIVE SUMMARY

It is widely thought that the United States has a "200 year" supply of cheap coal. The truth of this statement, however, has not often been carefully examined combining both financial and geological information.

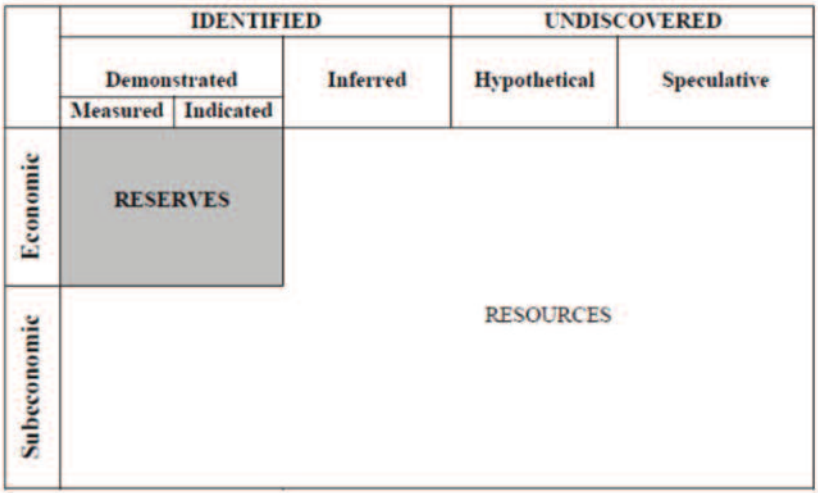
After examining currently available geological and financial data, there is good reason to believe we are rapidly reaching the end of US coal deposits that can be mined at a profit. If coal can't be mined at a profit, not much of it will be mined. It is unclear how long the US coal industry will produce large quantities of coal and at what price, but the current financial distress of US coal mining companies could lead to significant changes in US coal production in less than a decade.

EIA Estimates of "200 Years" of Coal "Reserves" Has Been Like a Faulty Fuel Gauge

The fundamental problem with respect to the reporting of US coal supplies is that the Energy Information Administration ("EIA"), in the US Department of Energy ('DOE"), has long published a number for what it terms "Estimated Recoverable Reserves" for US coal supplies of over 200 billion tons. EIA's published "Estimated Recoverable Reserves" equates to a supply of over 200 years at current rates of consumption, but this number has never been analyzed for economic recoverability—the key determinant of what are properly classified as "reserves." (See Part 1) A more accurate categorization for many US coal deposits would be as technically recoverable "resources," not as economically recoverable "reserves."

Figure ES-1: Classification of Coal Resources and Reserves

Redrawn from Chapter D of the USGS National Coal Resource Assessment[1]



1 The National Coal Resource Assessment is compiled at http://pubs.usgs.gov/pp/1625f/ . The United States Geological Survey is in the Department of the Interior.

By referring to US coal deposits as "reserves" when they are more properly classified as "resources," the EIA has misled the United States into thinking it has a "200 year" supply of easily accessible coal—which it does not. In short, the EIA's reporting of over 200 billion tons of "Estimated Recoverable Reserves" for US coal supplies has been like a "faulty fuel gauge" for US coal estimates.

USGS Studies Indicate That Only a Small Percentage of US Coal is Likely to Be Economically Recoverable

Rather than having a "200 year" supply of coal, there is now abundant evidence that the US is rapidly approaching the end of economically recoverable coal.

The United States Geological Survey has undertaken a series of studies that indicate that only a small percentage of coal resources are likely to be economic to recover. These USGS studies have been part of the National Coal Resource Assessment ("NCRA") and have typically found that less than 20% of US coal formations will be economically recoverable. (See Part 2)

While the amount of economically recoverable coal will ultimately depend on the outcome of many complex variables of supply and demand, it is clear that most US coal is buried too deeply to be reasonably accessible and only a small fraction of the "200 year" supply of coal will be mined at a profit.

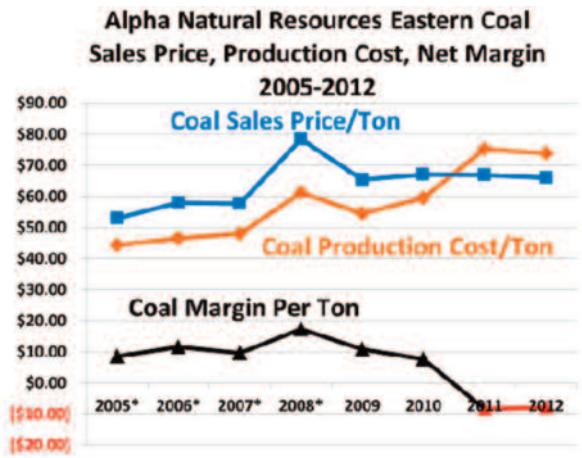
Of significant concern is that about 40% of the country's coal comes from a few large coal mines in the Powder River Basin of Wyoming. The largest of these mines produce more coal than all but the top two coal producing states. Importantly, many of the largest US coal mines appear to have significantly less than 20 years of remaining coal and the coal in proposed expansion areas is buried more deeply than the coal that is being mined currently. Given the current financial strains affecting US coal companies, it is unclear whether they will be able to support the increased capital and labor costs associated with mining coal that is more difficult to access.

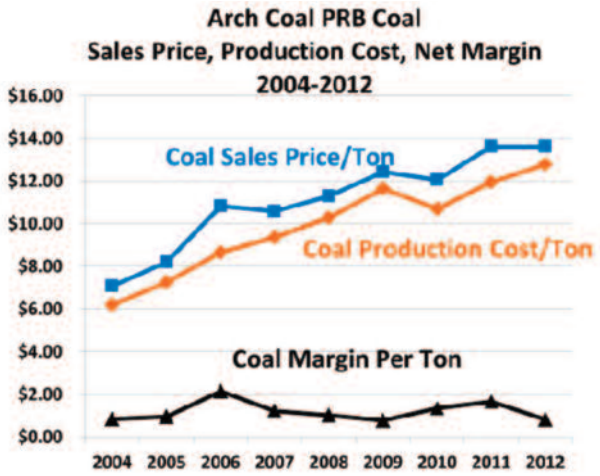
US Coal Companies are Facing Rising Production Costs and Declining Profit Margins

Studies by the USGS and others indicate that much of the coal remaining in the US is buried too deeply to be easily accessible. As US coal companies turn to harder-to-access coal deposits, the cost to produce the coal increases. (See Part 3) As the cost to produce US coal increases, coal company

Figure ES-2: Impact of Rising Production Costs on Profit Margins for Eastern and Powder River Basin Coal Mines

(Data from Year End and 10-K Annual Reports for the indicated coal companies.)





profit margins have thinned and for some producers, profit margins have become negative—particularly from eastern mines.

While production costs have risen and profit margins have thinned or become negative, mine productivity has fallen steadily from 6.99 tons per employee per hour in 2000 to 5.19 tons per employee per hour in 2012.

Rising production costs, declining productivity and thinning or negative profit margins have played a significant role in the serious financial duress facing many US coal companies with several top US coal companies reporting large losses and negative returns per share and return on investment. While it is possible that rising prices for natural gas (the primary fossil fuel alternative to coal for producing electricity) may help alleviate the financial distress of US coal companies, the financial issues related to the increasing cost of producing coal are likely to plague the US coal industry from here on.

Cost of Coal to US Utilities and Their Customers is Rising 2 to 3 Times Faster than Inflation

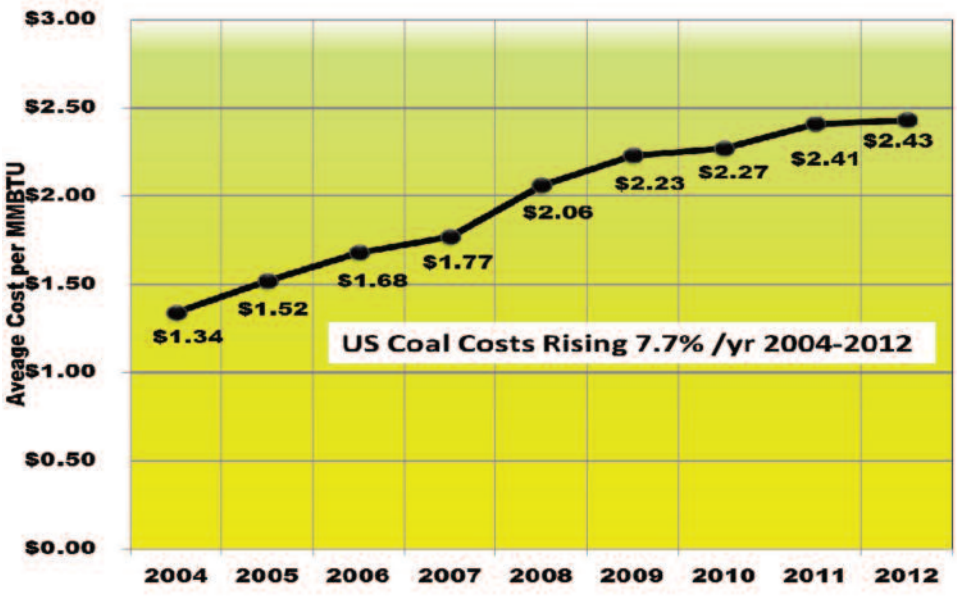
The cost of coal used by electric utilities has been generally rising steadily—often rising in many states at a rate of 6-10% per year or 2-3 times faster than inflation over the last decade. (See Part 3) Since 2004, average US delivered coal costs have increased at a rate above 7% per year. If coal costs increase at a rate of more than 7% per year, they will double in less than a decade—as they have done in a number of states since 2004.

Many utilities pass the cost of coal and natural gas through to their customers and so the utilities do not feel the strain of higher fuel costs directly. Moreover, customers often have a hard time deciphering their utility bills and consequently, the implications of coal costs rising much faster than inflation are not widely recognized or understood. It does not appear, however, that coal can continue to double in cost in a decade or less and retain its reputation as a cost-effective source of electricity for much longer.

Figure ES-3: US Delivered Coal Costs 2004-2012

Data from EIA Electric Power Monthly http://www.eia.gov/electricity/monthly/

(Year end data are usually in the February or March report for the previous year.)



While the details of coal cost and supply vary by region, the cost of coal has risen significantly in states from all different regions of the United States as shown in Table ES-1 below. In 2012, coal costs were often dampened by competitive pressure from natural gas which could often be purchased for less than $3/MMBTU. As natural gas costs increase in coming years, this damper on the cost of coal will likely abate. Data and graphs for all states that report coal costs are available in a report, "Trends in US Coal Costs 2004-2012," available from Clean Energy Action.

Table ES-1: 2004 and 2012 Delivered Coal Costs—Selected States

Data for Electric Utilities from EIA Electric Power Monthly. Compound increase calculated from data shown.
http://www.eia.gov/electricity/monthly/

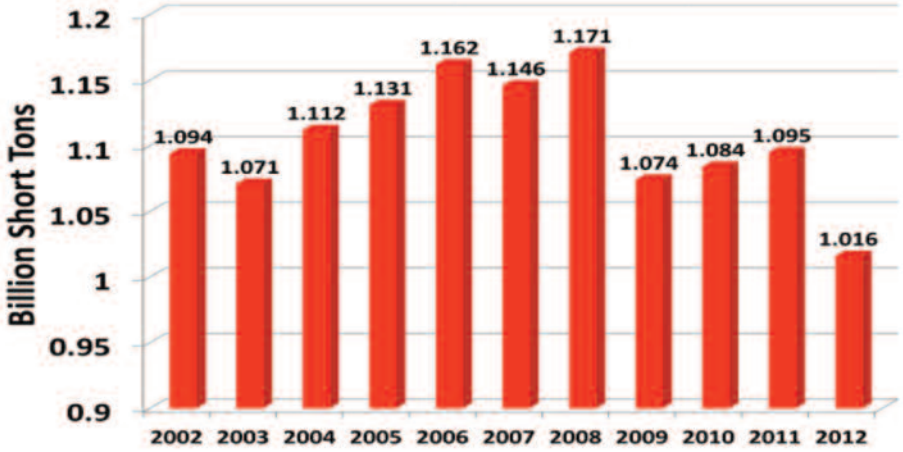
State	2004 Delivered Coal Costs $/MMBTU	2012 Delivered Coal Costs $/MMBTU	2004-2012 Compound % Increase/Year
Alabama	$1.51	$3.00	8.96%
Colorado	$0.97	$1.85	8.41%
Florida	$1.89	$3.49	7.97%
Georgia	$1.79	$3.47	8.63%
Illinois	$1.16	$2.08	7.57%
Indiana	$1.21	$2.60	10.03%
Iowa	$0.90	$1.48	6.41%
Kentucky	$1.39	$2.44	7.29%
Louisiana	$1.37	$2.87	9.68%
Maryland	$1.74	$3.62	9.59%
Michigan	$1.37	$2.92	9.92%
Minnesota	$1.06	$1.98	8.12%
Mississippi	$1.73	$4.45	12.54%
Missouri	$0.92	$1.86	9.2%
Montana	$0.63	$1.52	11.64%
New Jersey	$2.27	$4.05	7.50%
New Mexico	$1.48	$2.18	4.96%
New York	$1.58	$3.20	9.22%
Ohio	$1.32	$2.41	7.81%
Pennsylvania	$1.23	$2.46	9.05%
Virginia	$1.90	$3.61	8.35%
West Virginia	$1.41	$2.70	8.46%
Wisconsin	$1.16	$2.37	9.34%
Wyoming	$0.86	$1.44	6.65%
US Total	**$1.34**	**$2.43**	**7.72%**

The United States is Likely Past Peak Coal Production

While no one knows what the future will bring, the United States appears to be past "peak coal" with coal production falling off significantly since the apparent peak in US production in 2008. In addition, all of the top 16 coal producing states appear to be past peak—even the large coal-producing western states of Wyoming and Montana.

Figure ES-4: US Coal Production 2002-2012

Data from EIA Annual Coal Reports http://www.eia.gov/coal/data.cfm

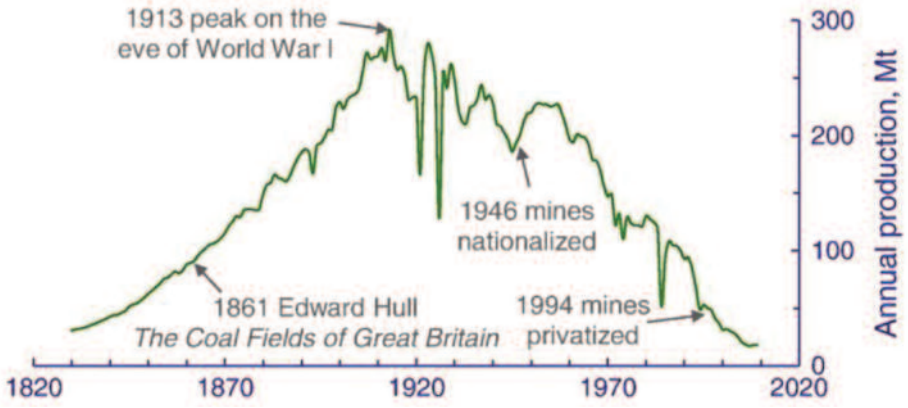


Cautionary Tales: Non Renewable Resources Do Not Renew

Review of what happens in "mature" coal regions around the world and in the United States can serve as "cautionary tales" for the decline of coal mining in states and regions that are currently heavily dependent on coal mining for employment, taxes and support of the local economy. (See Part 4) As coal mines play out, coal-dependent regions need to either find an alternative source of economic activity or fall into decline. Figure ES-5 shows what has happened to coal production in Britain over the last two centuries.

Figure ES-5: Britain's Coal Production 1820-2010

From http://www.its.caltech.edu/~rutledge/DavidRutledgeCoalGeology.pdf



Utilities that fail to understand US coal supply constraints can end up making large capital investments in coal plants that may not be economical to operate and the capital investment can then become stranded. (See Part 4) Utilities and investors have already made investments of hundreds of millions of dollars or more in coal plants that have either been lost or are likely to become stranded, including:

- The legendary investor Warren Buffett, has written off over $1.3 billion in investment in the heavily coal-dependent Energy Future Holdings of Texas.
- AES Eastern lost several hundred million dollars when two New York coal plants went bankrupt and were sold to bond holders for $240 million while their original cost was approximately $550 million.
- The decision by First Energy to idle the huge Sammis coal plant in Ohio after investing over $1.8 billion in pollution upgrades.
- The decision by Energy Capital Partners to close the 1500 MW Brayton Point coal plant in Massachusetts despite a recent investment of over $1 billion on upgrades.
- The decision by Xcel Energy to invest approximately $1 billion in a new coal plant in Pueblo, Colorado that was intended to operate until 2069 without first assessing long term coal supplies and which could become a stranded asset long before 2069.

US Coal Companies are Experiencing Serious Financial Distress and An Uncertain Future

Top US coal companies are in serious financial distress, with many coal companies reporting large losses in the last several years. Many US coal companies are carrying large amounts of debt that greatly exceed their market value and are paying interest rates in excess of 6%. (See Part 5)

Table ES-2: Market Capitalization and Debt for Top 3 US Coal Companies

Company	Market Capitalization September 17, 2013	Debt Reported in 2012 Year-End 10-K Report
Peabody Energy ("BTU")	$4.39 Billion	$6.25 Billion
Arch Coal Inc ("ACI")	$1.01 Billion	$5.08 Billion
Alpha Natural Resources ("ANR")	$1.4 Billion	$3.29 Billion

It is unknown what the future holds for the US coal industry, but there could be significant disruptions in the next 5 to 10 years as several top US coal companies have lost over 80% of their stock value and are facing debt payments in the next 3-7 years that already have interest costs of 6% and above. For example, as of the end of 2012:

- #1 US coal company, Peabody Energy, has $650 million of 7.375% debt due in 2016, $1.5 billion of 6% debt due in 2018, $650 million of 6.5% debt due in 2020 and $1.34 billion of 6.25% debt due in 2021.
- #2 US coal company, Arch Coal Inc., has $600 million of 8.75% debt due in 2016, $1 billion of 7% debt due in 2019, $375 million of 9.875% debt due in 2019 and $500 million of 7.25% debt due in 2020.
- #3 US coal company, Alpha Natural Resources, has $500 million of 9.75% debt due in 2018, $800 million of 6% debt due in 2019 and $700 million of 6.25% debt due in 2021.

Patriot Coal has already filed for bankruptcy and other companies, including Arch Coal and Alpha Natural Resources, have been put on bankruptcy watch.

Only time will tell whether the major US coal companies will survive the financial challenges they are facing in the next several years (See Part 6). To ensure proper economic planning, decision-makers from all sectors should begin examining the situation of US coal supplies carefully and consider scenarios that require the US to repower while retaining grid stability with coal supplies that could become seriously constrained in the not too distant future.

Many reports have been written about the problems of coal and climate change and the need for expensive pollution controls on US coal plants. Other reports have been written about the impact on coal of the availability of "cheap" natural gas made available through horizontal wells and hydraulic fracturing. This report is not about the impact on the US coal industry of the need for expensive pollution controls or the impact of "cheap" natural gas.

Rather, this report is about the "front end" supply problems facing coal and the fact that the US is getting very near the end of the supply of economically recoverable coal. In short—this report is about the front end cost and supply issues of coal and the financial consequences of having mined a non-renewable resource intensively for over 150 years.

The point of this report is that the fundamental constraint on coal is not from natural gas prices or government regulations, but from the geology of coal. The fundamental fact is that most of the coal in the US is buried too deeply to be accessed easily and we are rapidly approaching the end of accessible US coal deposits that can be mined profitably. If coal can't be mined at a profit, not much of it will be mined.

While no one can predict the future, decision makers at all levels and in all sectors of the economy would be wise to review the available evidence and then begin planning as though the United States has had a faulty fuel gauge on its coal supplies. Instead of assuming that the US has a "200 year" supply of easily accessible coal, Americans should begin to consider that we are likely reaching the end of coal that can be mined at a reasonable cost and that we could need to repower the US economy in the near future—for no other reason than constraints on the availability of reasonably priced coal.

Independent of arguments about climate change and clean coal, coal's days are very likely numbered due to questions of economic supply. Even if coal were perfectly clean—or could be made to be so—it would still be the wrong choice due to serious questions about long term US coal supplies.

PART 1:
Faulty Fuel Gauge on US Coal Supplies—Reporting of US Coal Reserves by the Energy Information Administration

The United States Energy Information Administration ("EIA") in the Department of Energy is the logical place to turn to learn about U.S. coal reserves. Unfortunately, as described below, the EIA's reporting of US coal reserves is not based on careful analysis of economic recoverability. The result is that EIA is serving as a "faulty fuel gauge" for anyone wanting to know about US coal reserves.

A. EIA is Reporting "200 Years" of Coal Reserves When It Has Never Examined those "Reserves" for Economic Recoverability

Each year the EIA in the Department of Energy publishes a number for US coal "reserves" that has misled our country into thinking we have a 200 year supply of "cheap" coal, when the truth is very different.

The EIA publishes its "Estimated Recoverable Reserves" or "ERR" for US coal in Table 15 of its Annual Coal Report.[2] At the end of 2011, EIA published Estimated Recoverable Coal "Reserves" for the United States as over 258 billion tons of coal.[3] Since the United States mines about 1 billion tons of coal a year,[4] the EIA's publication of 258 billion tons of Estimated Recoverable Reserves is a primary reason why it is widely thought that the United States has a "200 year" supply of coal. Unfortunately, what EIA is publishing as coal "reserves" are not reserves at all.

A key attribute required to classify coal resources as reserves is that they must be economically recoverable as shown in Figure 1 below (redrawn for clarity) from Chapter D of the United States Geological Survey's National Coal Resource Assessment. As shown in Figure 1, "reserves" is a small subset of "resources," with the primary requirement for "reserves" is that they have to be both demonstrated **and** economic to produce, meaning they can be produced at a price that provides a profit for the coal mining company.

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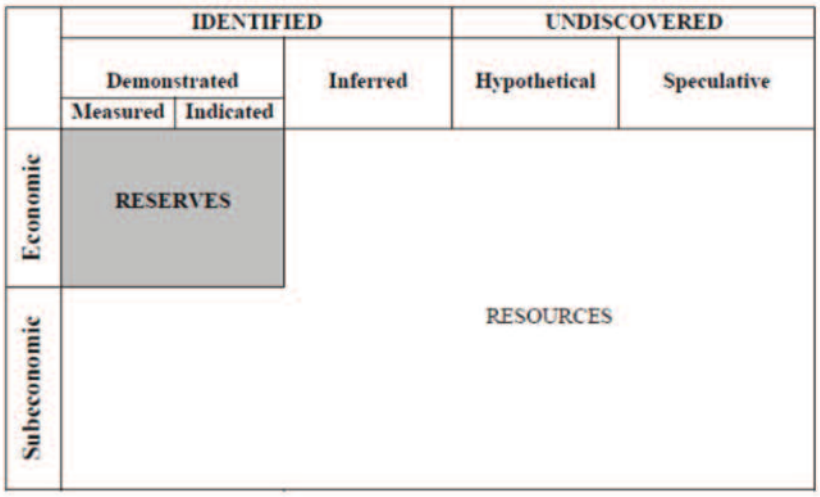
2 EIA's Annual Coal Report, including Table 15, is available at http://www.eia.gov/coal/annual/

3 The direct link for Table 15 of EIA's Annual Coal Report is http://www.eia.gov/coal/annual/pdf/table15.pdf . Estimated Recoverable Reserves for the United States was published as 258,619 million short tons for 2011. This is the same as 258.6 billion short tons.

4 http://www.eia.gov/coal/annual/ (Table 6)

Figure 1: Classification of Coal Resources and Reserves

Redrawn from Chapter D of the USGS National Coal Resource Assessment[1]



As can be seen from Figure 1 above, only a subset of coal resources are properly called coal "reserves." Reserves need to be economic to produce—meaning that they can be produced at a price that will earn a profit when sold on the market.

The USGS describes the difference between resources and reserves as follows:

> The use of the terms coal "resources" and "reserves" can be confusing. Although the two terms are frequently used interchangeably, there are significant differences…. **Coal reserves are a subset of the coal resources (fig. 1). To be classified as reserves, the coal must be considered as economically producible at the time of classification,** but facilities for extraction need not be in place and operative (Wood and others, 1983)….Typically, the volume of coal reserves in a given area is significantly smaller than total coal resources.[6] (Emphasis added.)

A primary source of confusion in understanding US coal supplies is that the EIA's 258 billion tons of "Estimated Recoverable Resources" of coal have never been analyzed for their economic recoverability. EIA's Estimated Recoverable Reserve number appears to have originated in the 1980s,[7] but when the EIA issued its 1997 update of its "Coal Reserves Data," it offered this warning:

> **The usual understanding of the term "reserves" as referring to quantities that can be recovered at a sustainable profit <u>cannot</u> technically be extended to EIA's estimated recoverable reserves** because economic and engineering data to project mining and development costs and coal resource market values are not available. (Emphasis and underlining added.)[8]

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5 The National Coal Resource Assessment is compiled at http://pubs.usgs.gov/pp/1625f/. The United States Geological Survey is in the Department of the Interior.

6 Chapter D, page 1, The National Coal Resource Assessment available at http://pubs.usgs.gov/pp/1625f/

7 Correspondence from EIA to the author, November 2011.

8 This quote from EIA was originally found at the following url: http://www.eia.gov/404r.cfm?v=http://www.eia.gov/cneaf/coal/reserves/chapter1.html .That webpage is no longer active. Paper copies of the original webpage with the referenced quote are available from the author and a scan of the page is posted on the Clean Energy Action webpage at www.cleanenergyaction.org.

In short, the EIA has acknowledged that what it calls "Estimated Recoverable Reserves" for coal are not actually "reserves." This is the source of the "faulty gauge" that has misled the United States into thinking it had a "200 year" supply of easily accessible coal.

The EIA can not calculate the amount of coal that should properly be designated "reserves" because, as the agency acknowledges in the quote above, the EIA does not have the data to calculate projected mining costs or the value of the coal on the market—the information needed to determine economic recoverability. Without information on the costs of mining and the ability to mine the coal at a profit, it is impossible to determine how much coal should be designated as "reserves."

As discussed in Part 2, the United States Geological Survey has conducted assessments of the amount of economically recoverable coal and found that it is typically a small fraction of the coal resources in the ground. As discussed in Parts 3 through 6, the issue of how much coal can be mined profitably is a difficult question that depends on a variety of complex financial and market variables.

The EIA has not assessed its "Estimated Recoverable Reserves" of coal for economic recoverability and these coal deposits are more properly labeled as "Estimated Recoverable Resources." The amount of US coal that can be recovered profitably is likely a very small fraction of the "200 Year" supply of coal that is often quoted.

B. The Idea that the US Has a "200 Year" Supply of "Cheap" Coal Is Based on "Reserve to Production" (R/P) Ratios: R/P Ratios Have Very Seldom Been Correct

In addition to the EIA not having analyzed its published "Estimated Recoverable Reserves" for economic recoverability, the concept of a "200 year" supply of coal for the United States is also questionable because it is based on a calculation of "Reserves to Production," and Reserves-to-Production ratios are very seldom accurate.

The standard reasoning has been that if the EIA published number for Estimated Recoverable " Reserves" is 258 billion[9] and the United States produces about 1 billion tons of coal annually,[10] then a ratio of so-called "reserves" to production of 258 to 1 gives "over 200" years of coal "reserves." The two problems with that estimate are:

1) What EIA calls coal "reserves" are not really reserves at all; and
2) Determining long term coal production based on "reserves-to-production" ratios is very seldom correct.

Professor David Rutledge at Caltech has analyzed early claims for "reserves" and compared them to what is likely to be total long term production and found that actual production is typically a fraction of what was predicted from early estimates of coal "reserves"[11] as shown in Table 1 below.

9 See Table 15 in the EIA Annual Coal Report available from http://www.eia.gov/coal/annual/

10 See Table 1 in the EIA Annual Coal Report available from http://www.eia.gov/coal/annual/

11 See page 11 at http://www.its.caltech.edu/~rutledge/DavidRutledgeCoalGeology.pdf

Table 1: Reserve Estimates to Actual Coal Production for Mature Coal Regions

Data from page 11 in http://www.its.caltech.edu/~rutledge/DavidRutledgeCoalGeology.pdf

Region	Early Estimate of Reserves	Current Estimate of Actual Long Term Production	Likely Actual Production as % of Early Reserve Estimate
United Kingdom	153 Gt	28.9 Gt	19%
Pennsylvania (Anthracite)	12 Gt	5.05 Gt	42%
France and Belgium	33 Gt	7.6 Gt	23%
Japan and South Korea	17 Gt	3.7 Gt	21%

As shown in Table 1 above, the actual production of coal is often a relatively small fraction of the early "reserve" estimates, with several areas only producing about 20% of the original "reserve" estimate.

Professor Rutledge[12] and the German Energy Watch Group[13] have documented the tendency for estimates of coal "reserves" to be significantly reduced with what were formerly classified as "reserves" being reclassified as "resources." Professor Rutledge goes on to say:

> In his 1979 classic, World Coal Reserves, (Fettweis, 1979) Gunter Fettweis indicated that in the German-speaking world, there was a minerals category that he translated into English as occurrences (*Vorkommen* in German). Fettweis used this word to describe deposits that were not of economic interest.[14]

While there are billions of tons of coal buried under the United States, it is becoming increasingly likely that most of this coal cannot be mined at a profit and would perhaps best be categorized as resources—or even more accurately as coal "occurrences."

C. Despite a Front Page Story in the *Wall Street Journal* in 2009 Questioning the EIA's Coal "Reserve" Reporting, the EIA has Not Changed Its Practice

On June 8, 2009, the *Wall Street Journal* ran a front page article[15] by energy reporter Rebecca Smith questioning the Energy Information Administration's reports of US coal "reserves." The article concluded that the EIA's coal-reserve estimate "may be wildly overconfident" and that while there is a lot of coal under the United States, "relatively little of it can be profitably extracted." The article concluded:

> The Energy Information Administration, part of the Department of Energy, says it is reassessing its coal tally in light of the new Geological Survey data. It intends to create a new coal baseline from which it will begin its annual subtraction "as soon as we can," says William Watson, a member of the energy analysis team at EIA in Washington, D.C.[16]

12 See pages 10-11 at http://www.its.caltech.edu/~rutledge/DavidRutledgeCoalGeology.pdf

13 See http://www.energywatchgroup.org/fileadmin/global/pdf/EWG_Report_Coal_10-07-2007ms.pdf

14 See page 11 at http://www.its.caltech.edu/~rutledge/DavidRutledgeCoalGeology.pdf.

15 See http://online.wsj.com/article/SB124414770220386457.html

16 From http://online.wsj.com/article/SB124414770220386457.html

Despite this front-page story in the *Wall Street Journal* and an indication that EIA knew that it needed to create a new baseline for its estimates of US coal reserves, four years later there is no indication that EIA has undertaken any serious effort to reassess how it reports US coal reserves. The failure of the EIA to properly report how much US coal is economically recoverable has permeated many government and industry analyses.

For example, in November 2010, the Congressional Research Service published a report, "U.S. Fossil Fuel Resources: Terminology, Reporting and Summary," and noted with respect to coal reserves, that "very large coal numbers are viewed with some caution because in-place numbers may not provide a realistic assessment of the coal that could actually be produced."[17] Unfortunately, the CRS went on to provide estimates of total "Fossil Fuel Reserves" that assume very large amounts of U.S. coal reserves[18] without assessing how much of these coal deposits can be produced at a profit.

The determination of coal "reserves" is a complex task with the variables related to coal mine production costs and market value of the coal undergoing constant fluctuations. It appears the easiest and most accurate way for the EIA to resolve the issue would be to change its "Estimated Recoverable Reserves" to "Estimated Recoverable **Resources**," and then allow economists and industry analysts to issue "reserve" estimates based on the evolving data on coal production costs and market value as well as the cost of alternatives and coal company financial strength.

Estimating coal reserves depends on a host of complex variables related to the cost of producing the coal and of supply and demand for coal and other alternative fuels and technologies. It appears the best course at this point would be for the EIA to report "Estimated Recoverable Resources" and allow other analysts to estimate remaining US coal reserves based on the evolving data on coal production costs, market value, cost of alternatives and coal company financial status.

17 See page 13, http://www.epw.senate.gov/public/index.cfm?FuseAction=Files.view&FileStore_id=04212e22-c1b3-41f2-b0ba-0da5eaead952

18 Page16-18 in, http://www.epw.senate.gov/public/index.cfm?FuseAction=Files.view&FileStore_id=04212e22-c1b3-41f2-b0ba-0da5eaead952

PART 2:
The Immutable Geology: Signs that the US is Coming to the End of Economically Recoverable Coal

A review of the available geologic studies and data on production[19] indicate that the United States is very likely past "peak coal" and is rapidly approaching the end of easily accessible coal that can be mined at a profit.

A. Studies by the US Geological Survey Indicate that Only a Small Percentage of US Coal Is Likely to Be Economically Recoverable

Beginning in the late 1980s, the United States Geological Survey ("USGS") began assessing US coal resources for their availability and economic recoverability. The results have been collated in the National Coal Resource Assessment which is available online at http://pubs.usgs.gov/pp/1625f/ .

As shown in Figure 2, below, the results of the USGS studies published as part of the National Coal Resource Assessment indicate that in most cases, less than 20% of the original coal in the US is expected to be economically recoverable. The amount of coal in coal fields around the country that was considered to be economically recoverable is shown by the pink bottom bar in the USGS graphs in Figure 2. The green bar that is second to the bottom represents coal that is technically recoverable given current technologies without consideration of economic profitability. As shown by the USGS, only a relatively small percentage of technically recoverable coal is likely to be economically recoverable.

Also, the USGS notes that studies of economic recoverability need to be updated on a regular basis to reflect changes in the various cost and market variables.

> It should be noted that a coal-reserves assessment is not a one-time evaluation or static procedure. The volume of reserves calculated is dependent on the information/data and assumptions used at the time of the study. Significant changes in parameters such as transportation, changes in technology, mining economics, and demand for coal and market pricing will affect the estimates of reserves through time.[20]

19 For background information on US coal production, the reader is referred to the 2009 report "Coal Cheap and Abundant—Or is It: Why Americans Should Stop Assuming that the US has a 200 Year Supply of Coal" available from http://cleanenergyaction.files.wordpress.com/2011/10/coal_supply_constraints_cea_0212091.pdf

20 See page 4, Chapter D, National Coal Resource Assessment, available from http://pubs.usgs.gov/pp/1625f/

Figure 2: Economically Recoverable Coal in Key US Coal Beds

Data from the USGS National Coal Resource Assessment, Chapter D, page 12.

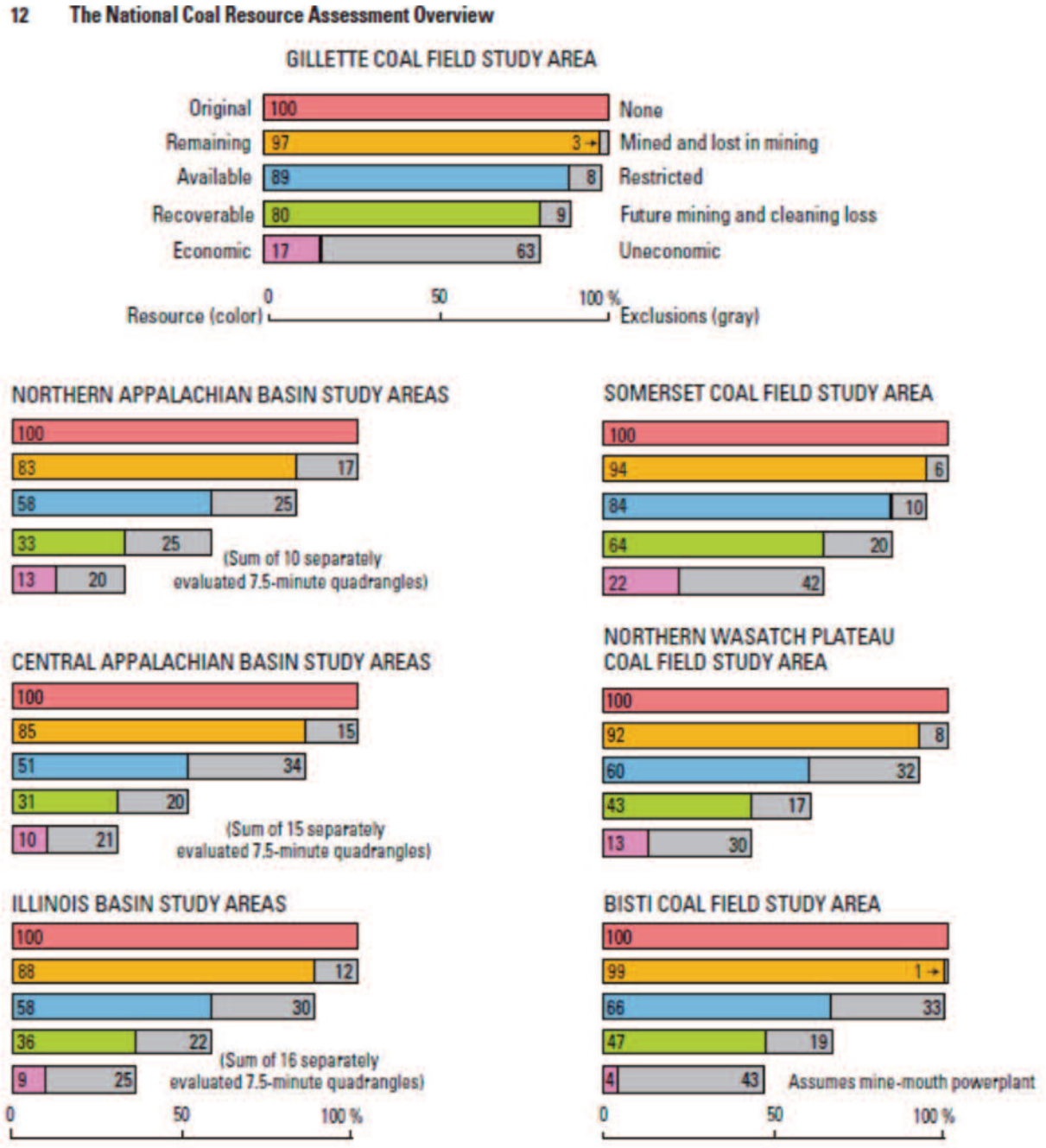

Figure 5. Coal availability/recoverability summary of coal basins resource evaluations from USGS Professional Papers 1625 A, B, C, and D.

Figure 2 shows the large difference between *technically* recoverable coal (the green bar) and *economically* recoverable coal (the bottom pink bar.) This difference is summarized in Table 2 below. Technically recoverable coal can be mined using technologies that are available, but no analysis is done of how the production cost compares to the sales price. Economically recoverable coal is coal that

can be produced at a cost that is either "break even" or allows for a profit. Economically recoverable coal is often less than 20% of the original coal bed studied as part of the National Coal Resource Assessments done by the USGS and summarized in Table 2.

Table 2: USGS Results for Economically Recoverable Coal in US Coal Fields

Data from National Coal Resource Assessment, Chapter D, page 12 as seen in Figure 2.[21]

Coal Field	Region or State	Technically Recoverable Coal	Economically Recoverable Coal
Gillette	Wyoming	80%	17%[22] (2002 Study)
Northern Appalachia	Eastern US	33 %	13%
Central Appalachia	Eastern US	31%	10%
Illinois Basin	Illinois	36%	9%
Somerset	Pennsylvania	64%	22%
Northern Wasatch	Utah	43%	13%
Bisti	New Mexico	47%	4%

As shown in Figure 1 of this report, coal resources include coal that is both economic and subeconomic to mine. As shown in Table 2 above, the percentage of coal that is economically recoverable is significantly smaller than the percentage of coal that is technically recoverable.

The USGS summarizes the relationship between total coal and economically recoverable coal as follows:

> ….the amount of economically recoverable resources for all the areas evaluated represents only a relatively small fraction (4 percent to 22 percent) of the original resources. This result **stresses the need to use coal resource terminology carefully, avoiding the use of the terms "resources" and "economically recoverable resources" interchangeably.** (Emphasis added.)[23]

The USGS studies on the amount of coal that is economically recoverable as shown in Figure 2 and summarized in Table 2 may be an optimistic estimate of economically recoverable coal given the financial distress being experienced by the US coal industry as discussed in Parts 3-6, below. Coal companies that are in financial distress are more reluctant to make the investments in machinery and labor that are needed to mine coal that is increasingly more difficult to access.

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21 Data from Chapter D, page 12, National Coal Resource Assessment http://pubs.usgs.gov/pp/1625f/ . Assessments of economically recoverable coal need to be updated regularly to reflect changes in both production costs and sales price so these numbers should be taken as indicative, not absolute.

22 Note that the 17% economically recoverable coal in the Gillette coal field came from a 2002 study. In 2008, that study was updated in USGS Open File Report 2008-1202 available from http://pubs.usgs.gov/of/2008/1202/. In 2008, despite a large increase in coal prices since 2002, the USGS cut the amount of economically recoverable coal in the Gillette coal field from 17% to 6%. See Figure 6.

23 See Chapter D, page 15, National Coal Resource Assessment http://pubs.usgs.gov/pp/1625f/ .

Detailed studies of economic recoverability of US coal supplies indicate that typically less than 20% of the original coal resource is likely to be economically recoverable. Claims that the US has a "200 year" supply of coal have not analyzed carefully how much of that coal will be economically recoverable—particularly given the current financial condition of US coal companies.'

B. Appalachian Coal Mines Are Playing Out After Over a Century of Intensive Mining

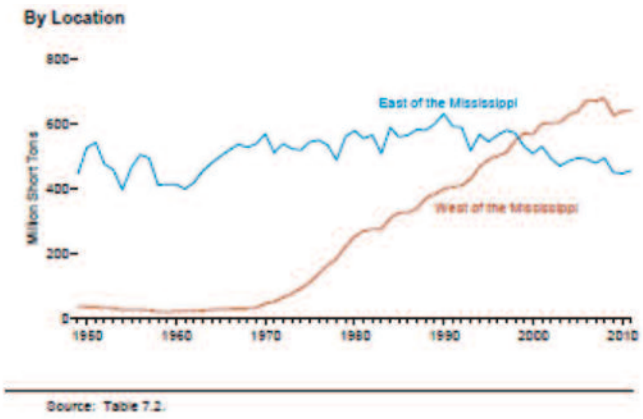
After over a century of intensive mining, the coal mines of Central Appalachia are beginning to play out and few, if any, analysts expect coal production from these coal deposits to remain vigorous for long. A recent analysis summarized the situation as follows:

> The Central Appalachian coal industry and the communities that depend on coal for jobs and revenues in southern West Virginia, eastern Kentucky, Virginia, and Tennessee are facing numerous challenges. These challenges include the depletion of the region's most productive coal reserves; declining labor productivity; rising coal prices; increasing rates for coal-generated electricity; and increasing competition from other coal basins, natural gas, and renewable energy technologies.[24]

Over the last 30 years as production from Appalachian coal mines has declined, while production from western US coal mines has increased. In the late 1990s, western US coal production surpassed eastern coal production as shown in Figure 3 below. Coal production in states east of the Mississippi River has fallen from a peak of 630.2 million tons in 1990[25] to 422.7 million tons in 2012.[26]

Figure 3: Coal Production by Region 1949-2011

Graph from Table 7.2 EIA Annual Review http://www.eia.gov/totalenergy/data/annual/index.cfm#coal



24 See "The Continuing Decline of Demand for Central Appalachian Coal: Market and Regulatory Influences," available from http://www.downstreamstrategies.com/projects.html and http://timesnews.net/article/9036238/central-appalachia-is-running-out-of-thick-easy-to-reach-seams-of-coal

25 See EIA Coal Industry Annual 1994, page 5, available from http://www.eia.gov/coal/annual/

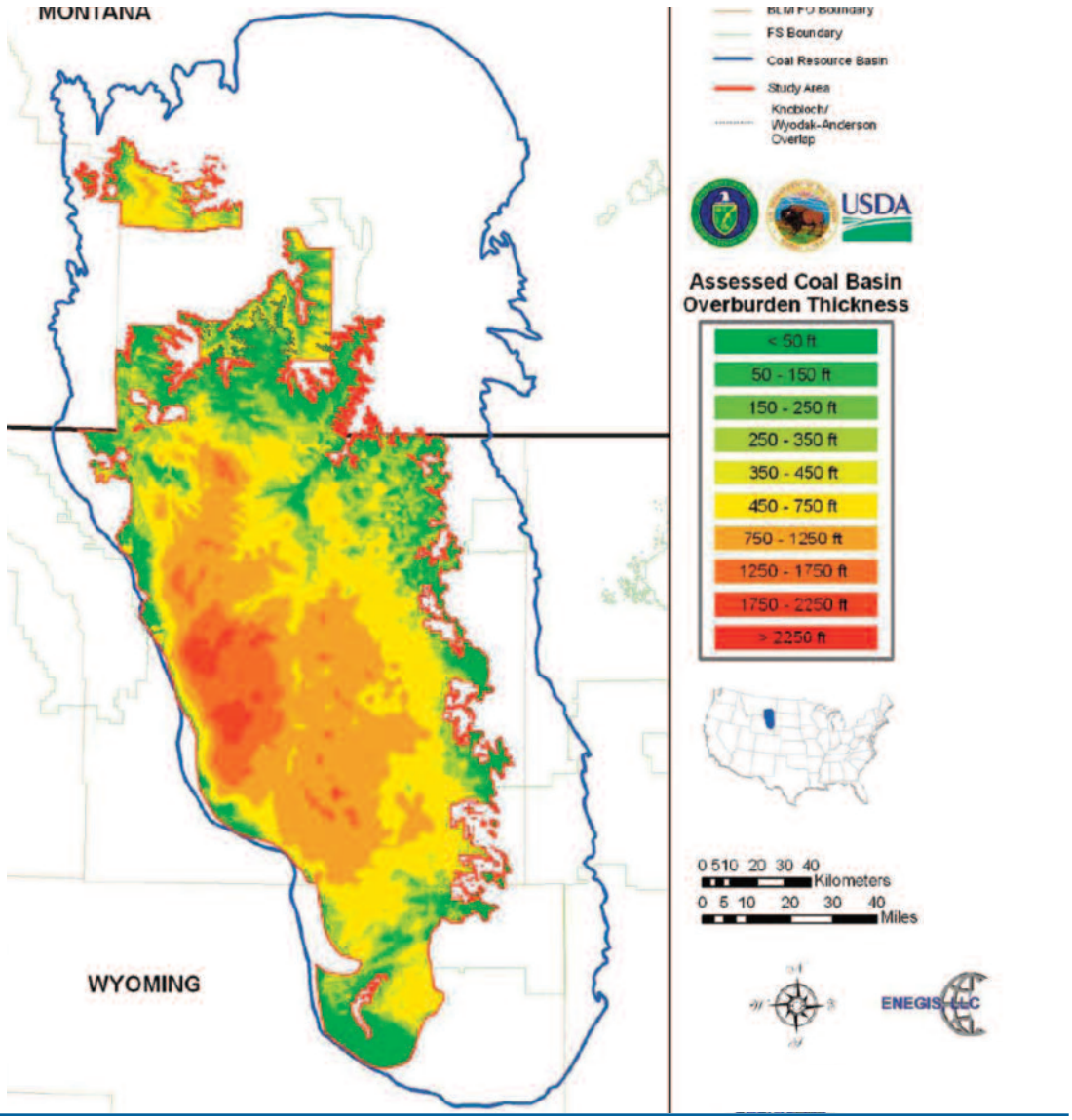
26 See EIA Quarterly Coal Report, 2012 Q4, page 7, available from http://www.eia.gov/coal/production/quarterly/

C. Most of the Remaining Coal in the Western US Is Not Likely to Be Profitable to Recover

Many Americans are under the assumption that there are vast amounts of US coal "out west." That is true. There are billions and billions of tons of coal in the Powder River Basin of Wyoming and Montana,[27] but the geologic fact is that most of it is buried too deeply to be mined at a price that will be profitable.

Figures 4 and 5 below provide a general view of the coal in the Gillette coal field, the largest coal field in the United States and the source of about 40% of our country's coal.[28] As can be seen from Figure 4, the coal in the Powder River Basin does not exist as a flat coal bed, but rather one that generally

Figure 4: General View of the Gillette Coal Field Overburden Thickness[29]



27 The amount of technically recoverable coal in the Powder River Basin of Wyoming and Montana has been estimated by the USGS at 162 billion short tons. See http://www.usgs.gov/newsroom/article.asp?ID=3518#.UYardZ3nblU .Technically recoverable means the coal can be mined using existing technology if price is no object. The USGS has estimated the economically recoverable coal in the Powder River Basin at 25 billion short tons. How much coal is actually mined will depend on the business and financial calculations of the coal companies—not on USGS studies.

28 See USGS 2008-1202 http://pubs.usgs.gov/of/2008/1202/

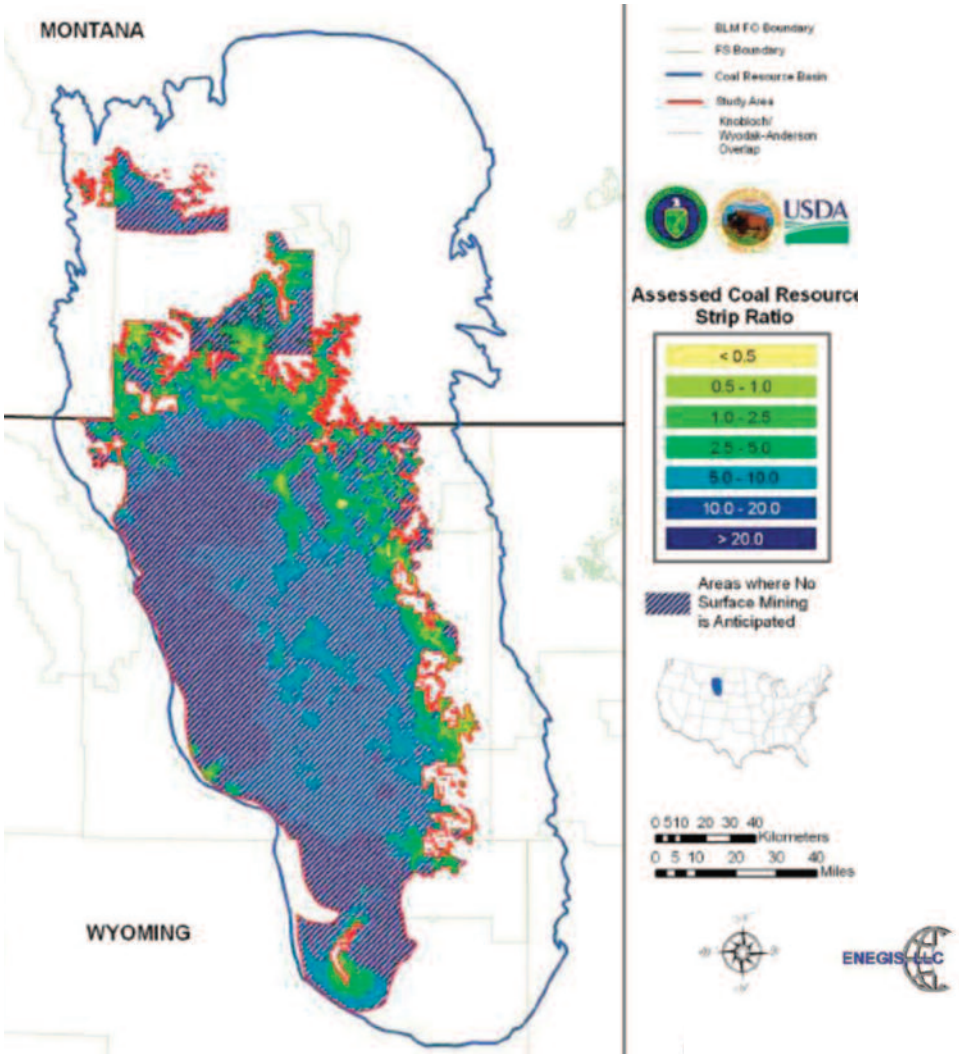
29 Figure 4 is taken from a 2007 report issued by the Department of Energy, Department of the Interior and Department of Agriculture.

slants downward going from east to west. On the eastern edge, the coal is only covered by 100-200 feet of overburden as shown by the green and yellow colors. In comparison, at the bottom of the basin on the western edge, the coal can be buried over 2000 feet deep as shown by the orange and red colors.[30]

The existing Wyoming coal mines in the Powder River Basin are on the eastern edge of the coal field seen in Figure 5 below. As they expand from east to west, the mines need to move increasingly large amounts of dirt to get to the coal.[32] The amount of dirt moved is expressed as a "stripping ratio," and is measured in bank cubic yards[33] of dirt moved to get to one ton of coal.

Figure 5: Coal Buried Too Deep to Be Surface Mined in the Gillette Coal Field[31]

Blue hatching indicates areas where No Surface Mining is Anticipated—



It was available at http://fossil.energy.gov/epact/epact437_final_rpt.pdf but that link is now broken. A copy of the original report is available from the author and will be posted at www.cleanenergyaction.org.

30 For a detailed review of the geology of the Gillette coal field, see USGS 2008-1202 available at http://pubs.usgs.gov/of/2008/1202/

31 Figure 5 is taken from a 2007 report issued by the Department of Energy, Department of the Interior and Department of Agriculture. It was available at http://fossil.energy.gov/epact/epact437_final_rpt.pdf but that link is now broken. A copy of the original report is available from the author and will be posted at www.cleanenergyaction.org.

In Figure 5, all of the areas of the Gillette coal field that are shown as blue stripes are areas where the coal in the Gillette coal field is buried very deeply with stripping ratios above 10:1 (i.e. mining companies would need to move 10 bank cubic yards of dirt to get to 1 ton of coal).[34] These areas are not expected to be surface mineable.

While it is possible that some of the coal in the Gillette coal field that is buried too deeply to be surface mined could be mined in underground mines or gasified in place to produce natural gas, it is unlikely that the scale of these operations could match the current production of about 400 million tons of coal a year (or about 40% of US coal)[35] that is currently mined out of the Gillette coal field in Wyoming.

As shown in Table 3, below, the large coal mines in Wyoming have a limited life span and the coal in proposed expansion areas is buried significantly deeper than the coal that has been mined in the last two decades. This is driving up the cost to produce the coal and adding to the financial stress facing the major US coal companies.[36]

Also, as discussed in Parts 3-6, US coal companies are facing serious financial hurdles including large debt payments that are coming due in the next 3-7 years. It is unclear if US coal companies that are under financial duress will be able to fund mine expansion into areas where the coal requires increasing amounts of capital and labor to produce. As production costs rise, it is unclear how much of the coal that is buried deeply in the Powder River Basin of Wyoming and Montana will be mined by companies that need to make a profit.

As a case in point, in August 2013, US coal company Cloud Peak, owner of the 3rd largest US coal mine, the Cordero Rojo in Wyoming, failed to bid on the Maysdorf II coal "lease" in Wyoming noting that given current coal costs and projected mining costs, the company was "unable to construct an economic bid" for the coal in this tract at this time.[37] This is apparently the first time that a Wyoming coal lease did not receive a bid.

Similarly, Cloud Peak has also announced that it will cut back on production at the Cordero Rojo mine because it could not justify the additional capital expenditure needed to maintain production. Cloud Peak's CEO described it as follows:

> The real catalyst for the decision was that to maintain the production in that area of the pit, we would actually have to add something like $50 million worth of capital for the truck shovel fleet, more people and more cost to maintain production if that area of the mine got deeper.[38]

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32 The CEO of Cloud Peak(fourth largest US coal company) described the situation in the Powder River Basin as follows in a 2013 Q2 conference call:

> And one thing I would add is that in terms of investment in the business we're actually having – we're employing extra people and with using extra equipment to make sure that we can actually deliver the tons we've contracted, and that's because in the Powder River basin every year to do the same amount of tons, because the coal dips, the hole distances increase, that you always need more – you have to do more work to get the same amount of coal. So whilst prices might be stable or flat to give the same 90 million tons of coal out, it's actually more work and more effort. And that's true for all producers in the basin because of the nature of the geography.

See http://seekingalpha.com/article/1692022-cloud-peak-energys-ceo-presents-at-barclays-capital-ceo-energy-power-conference-transcript?page=3

33 A bank cubic yard is a unit designating one cubic yard of earth or rock, measured or calculated before removal from the bank. See http://www.dictionaryofconstruction.com/definition/bank-cubic-yard.html

34 For details on the geology of all of the coal fields of the Powder River Basin refer to the USGS studies found at http://www.usgs.gov/newsroom/article.asp?ID=3518#.UYardZ3nblU .

35 See Table 1, Annual Coal Report at http://www.eia.gov/coal/annual/

36 For the effect of rising production costs in the Powder River Basin, see for example, http://www.platts.com/latest-news/coal/washington/power-river-basin-producers-finding-it-more-costly-21402408 and http://hanouenergy.com/services/powder_river_basin_coal_supply_demand_and_price_trends and

37 See http://online.wsj.com/article/PR-CO-20130821-909326.html

38 See http://www.snl.com/InteractiveX/Article.aspx?cdid=A-25043908-14886

While Wyoming has been thought to be the "Fort Knox" of US coal, it appears that most of the coal in Wyoming is buried too deeply to be surface mined and much of the coal that is easily accessible has already been mined. With several US coal companies under serious financial distress, it is unclear whether these companies will be able to finance coal mine expansion as the coal becomes more difficult and expensive to access.

C. Despite Rising Coal Prices, the Amount of Economically Recoverable Coal in the Gillette Coal Field of Wyoming Was Dramatically Reduced Between 2002 and 2008

The determination of economically recoverable coal reserves is a complicated undertaking involving analysis of many geologic and financial variables. In general, as the price of coal increases, one would expect the amount of economically recoverable reserves to also increase, but that is not always the case. In some situations, the cost to produce the coal will rise faster than the price that the coal can be sold for. Other times, there are other competing fuels or technologies that will reduce the marketability of the coal or new geologic information that affects the reserve determination.

One particularly interesting case is the dramatic reduction in economically recoverable coal in the Gillette coal field of Wyoming between 2002 and 2008.[39] Between 2002 and 2008, the price of coal was going up significantly.[40] With rising coal prices, one would normally have expected the amount of economically recoverable coal to increase. Instead the USGS adjusted its estimate of coal reserves in the Gillette coal field in 2008 by cutting the 2002 estimate by more than half.

As shown in Figure 6 below, the USGS reduced the estimate of economically recoverable coal in the Gillette coal field from about 23 billion tons (17 percent of the original resource)[41] to 10 billion tons (6 percent of the original resource.)

The reduction in economically recoverable coal reserves shown above in Figure 6 from 2002 to 2008 in the Gillette coal field of Wyoming resulted from several refinements in the data analysis that was conducted in 2008 including an increase in the number of well cores sampled from about 2,500 to about 6,000,[42] a recognition that when the coal was formed there were a number of stream channels that washed out significant quantities of coal[44] and a recognition that some coal would not be accessible due to the need to terrace the walls of the mining pit.[45]

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39 The Gillette coal field is the largest US coal field and typically the source of about 40% of US coal.

40 In 2002, the average cost of coal delivered to US utilities was $1.22/MMBTU. (MMBTU stands for million BTUs—a measure of the heat content.) In 2008, the average cost of coal delivered to US utilities was $2.05MMBTU. Average cost of delivered coal for US utilities is from the EIA Electric Power Monthly, Table 4.10B available at http://www.eia.gov/electricity/monthly/

41 The USGS 2002 study of the Gillette coal field was found at http://pubs.usgs.gov/of/2002/ofr-02-0180/ but then was taken off the USGS website with a note that it was being revised. A copy of the report is available from the author. The results of the 2002 USGS 2002-0180 study of the Gillette coal field are summarized on pages 3 and 4 of USGS 2008-1202 available at http://pubs.usgs.gov/of/2008/1202 .

42 See USGS 2008-1202, page 8 and Table 2.

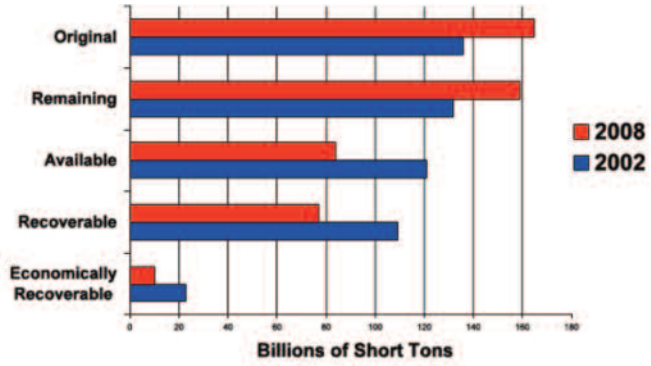
43 USGS 2008-1202 is available from http://pubs.usgs.gov/of/2008/1202

44 See USGS 2008-1202, page 14.

45 See USGS 2008-1202, Figure 61.

Figure 6: Reduction in Economically Recoverable Coal in the Gillette Coal Field of Wyoming from 2002-2008

Data from USGS 2008-1202, pages 1 and 4[43]



Determination of coal "reserves" is an on-going process that depends on complex geological and financial information for many different variables. In the absence of a significant and on-going commitment of budgetary, technical and personnel resources to make a determination of coal reserves, US coal deposits are most accurately classified as resources—not "reserves."

D. The Largest US Coal Mines Have Less Than a 20 Year Life Span

The largest US coal mines are in the Powder River Basin of Wyoming. These mines provide almost 40% of US coal.[46]

As can be seen from Table 3 on the next page, the top five US coal mines, providing almost 30% of US coal produced in 2011,[47] each have less than a 10 year life span as reported in Environmental Impact Statements prepared by the Bureau of Land Management in Wyoming.[48] A similar situation exists for the next five US coal mines also.[49]

46 In 2011, the surface mines of Wyoming provided 435,630 tons or about 39.8% of the total 1,093,977 tons of coal produced in the United States (other than refuse coal.)

47 2011 US coal production was about 1.09 billion tons according to the EIA 2011 Annual Coal Report, Table 1 found at http://www.eia.gov/coal/annual/pdf/table1.pdf . The top five mines produced about 315.8 million tons in 2011 or about 29% of US coal production. (Not including refuse coal.)

48 The BLM Environmental Impact Statements are prepared before the federal government "leases" coal that is owned by the federal government to the coal companies. While the sale of federally owned coal is referred to as "leasing," it is clear that the coal is not being leased for a term after which it will be returned.

49 The next five mines produced a little over 100 million tons or about another 10% of the US 2011 coal production. Four of these mines (Buckskin, Belle Ayr, Caballo and Rawhide) are in the Powder River Basin of Wyoming and the fifth (Spring Creek) is in Montana. The Wyoming mines all face similar geologic constraints to those summarized in Table 2, though detailed information is not available for all of these mines. The general geology of the Gillette coal field in Wyoming can be found in USGS 2008-1202 available from http://pubs.usgs.gov/of/2008/1202

Table 3: Remaining Life Span for Top 5 US Coal Mines and Overburden in Expansion Areas

Rank,[50] Name, and Location of Coal Mine	2011 Production[51]	Remaining Life of Mine (From BLM EIS's)[52]	Average Overburden in Existing Pit	Average Overburden in Expansion Area
#1 North Antelope Rochelle (Wyoming)	109 million tons	9.9 years Post-2008[53]	211 feet	240 feet[54]
#2 Black Thunder[55] (Wyoming)	104.9 million tons	9.3 years Post-2008[56]	282 feet	246-428 feet[57]
#3 Cordero Rojo (Wyoming)	39.5 million tons	11.4 years Post 2007[58]	215 feet	303 feet[59]
#4 Antelope (Wyoming)	37 million tons	11 years Post-2006[60]	122 feet	280 feet[61]
#5 Eagle Butte (Wyoming)	25.4 million tons	13.6 years Post-2005[62]	200 feet	325 feet[63]

50 Rank based on 2011 Production from Table 9 of the 2011 Annual Coal Report available at http://www.eia.gov/coal/annual/pdf/table9.pdf

51 2011 Production from Table 9 of the 2011 Annual Coal Report available at http://www.eia.gov/coal/annual/pdf/table9.pdf

52 Remaining life span was calculated based on data available at the time of the EIS. It is unclear what recent production patterns have done to the remaining lives of the largest US coal mines—but these numbers are not likely to be greatly increased and may be decreased.

53 See Wright Area EIA, page ES-23 at http://www.blm.gov/pgdata/etc/medialib/blm/wy/information/NEPA/cfodocs/westantelope/feis.Par.19906.File.dat/003exsumm.pdf .

In 2012, Peabody Energy purchased the North Porcupine and South Porcupine coal "leases" from the Bureau of Land Management and now reports 2.3 billion tons of coal reserves or over a 20 year supply. See page 31 and F-61, Peabody 2012 10-K available from http://www.peabodyenergy.com/content/162/SEC-Filings .

54 See Wright Area FEIS, Table 3-7 on page 3-14 at http://www.blm.gov/pgdata/etc/medialib/blm/wy/information/NEPA/hpdo/Wright-Coal/feis.Par.67516.File.dat/07chap3.pdf

55 Since the Final Environmental Impact Statement was written, Arch Coal acquired the Jacobs Ranch mine that adjoined the Black Thunder mine, increasing reserves for what is termed the "Black Thunder Complex." In its 2012 10-K Annual Report on page 14, Arch Coal indicated that current coal reserves at the Black Thunder mine "could sustain current production levels until 2021 before annual output starts to significantly decline." Arch Coal also notes the existence of federal coal reserves adjacent to the Black Thunder mine which could be "leased" from the federal government. As noted in Table 3 in the text, the coal in these expansion areas will likely be buried more deeply than the coal in the current Black Thunder complex.

56 See for example Wright Area FEIS page ES-19, at http://www.blm.gov/pgdata/etc/medialib/blm/wy/information/NEPA/cfodocs/westantelope/feis.Par.19906.File.dat/003exsumm.pdf .The Black Thunder has since been consolidated with the Jacobs Ranch mine. This will likely increase the remaining life of the Black Thunder mine, but it is not clear for how long.

57 See Wright Area FEIS, page 3-4 at http://www.blm.gov/pgdata/etc/medialib/blm/wy/information/NEPA/hpdo/Wright-Coal/feis.Par.67516.File.dat/07chap3.pdf

58 See South Gillette FEIS, page ES-15 at http://www.blm.gov/pgdata/etc/medialib/blm/wy/information/NEPA/hpdo/south_gillette/feis.Par.9723.File.dat/05_summary.pdf

59 See South Gillette FEIS, page 3-11at http://www.blm.gov/pgdata/etc/medialib/blm/wy/information/NEPA/hpdo/south_gillette/feis.Par.69474.File.dat/09_chap3.pdf

60 See West Antelope II FEIS, page ES-7 at http://www.blm.gov/pgdata/etc/medialib/blm/wy/information/NEPA/cfodocs/westantelope/feis.Par.19906.File.dat/003exsumm.pdf

61 See West Antelope FEIS, Chapter 3, page 3-8 at http://www.blm.gov/pgdata/etc/medialib/blm/wy/information/NEPA/cfodocs/westantelope/feis.Par.64401.File.dat/006chap3.pdf

62 See Eagle Butte FEIS, page ES-9 at http://www.blm.gov/pgdata/etc/medialib/blm/wy/information/NEPA/cfodocs/eaglebuttewestcoal/feis.Par.79934.File.dat/02abst-exsumm.pdf

63 See Eagle Butte FEIS, page 3-8 at http://www.blm.gov/pgdata/etc/medialib/blm/wy/information/NEPA/cfodocs/eaglebuttewestcoal/feis.Par.93601.File.dat/05chap3.pdf

As can be seen from Table 3, the top US coal mines all have less than a ten year life expectancy for their existing pits. While these large US surface mines can expand into new areas, the coal in these expansion areas is typically buried more deeply than in the existing pits as shown in Table 3, above.

Digging a mine is not a linear undertaking like drilling a well. As anyone knows who has dug a hole, it is a volumetric problem and it takes a lot of effort to move the extra dirt required to dig a deeper hole. The costs of moving this extra dirt and other rising costs are leading to increased production costs and thinning (or non-existent) profit margins as discussed below in Parts 3-6.
In addition, the large US surface mines need to be reclaimed under the Surface Mine Control and Reclamation Act (USC 30 USC §1201 et seq., Public Law 95-87).[64] Reclaiming the existing pits in Wyoming will add significant expense to the cost of producing coal and will likely further erode profit margins.

As discussed below in Parts 3-6, it is unclear how many more years US coal companies will be able to produce coal at a profit. If coal can't be mined at a profit, it is unclear how much more will be mined.

64 For more information on the Surface Mine Conrol and Reclamation Act, consult 30 USC §1201 et seq or go to http://www.osmre.gov/topic/smcra/smcra.shtm

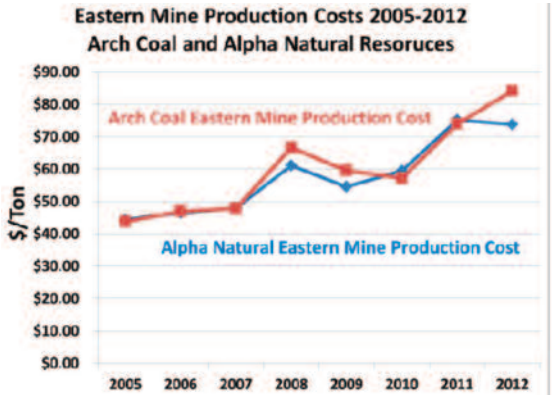
PART 3:
US Coal Industry—Rising Costs and Prices, Declining Profit Margins and Production

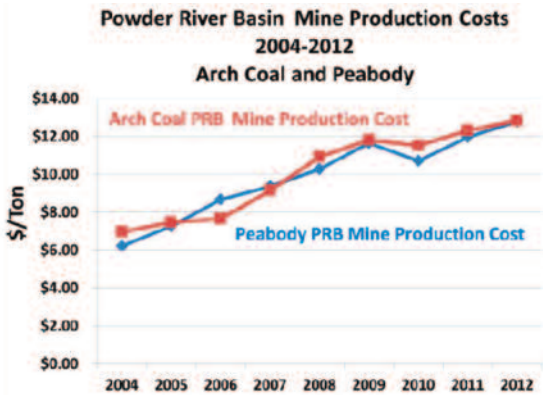
A. Coal Companies Are Facing Rising Production Costs as Most of the Easily Accessible US Coal Has Already Been Mined

The standard—and logical—way to mine non-renewable resources is to mine the easily accessible resources first and then move to harder to access and more expensive resources next. As would be expected, this is generally reflected in rising costs of production for the resource.[65] As the cost of production increases, then sales price must also rise in order to maintain the profitability of the mining companies. As shown in Figure 7 below, production costs have been rising for both eastern mines and for the Powder River Basin mines operated by the largest US coal operators.[66]

Figure 7: Rising Production Costs for Eastern and Powder River Basin Mines in the 21st Century

(Data from Year End and 10-K Annual Reports for the indicated coal companies.)





As seen in Figure 7 above, the cost to produce coal in both eastern and western coal mines has been rising steadily in the last decade. In many cases, this rise in production costs is 8-10% per year—or several times faster than inflation.[67]

With coal production costs rising quickly as shown in Figure 7 above, unless sales prices rise as fast or faster than production costs, then the profit margins for the coal companies can erode or disappear, as shown in Figure 8 below.

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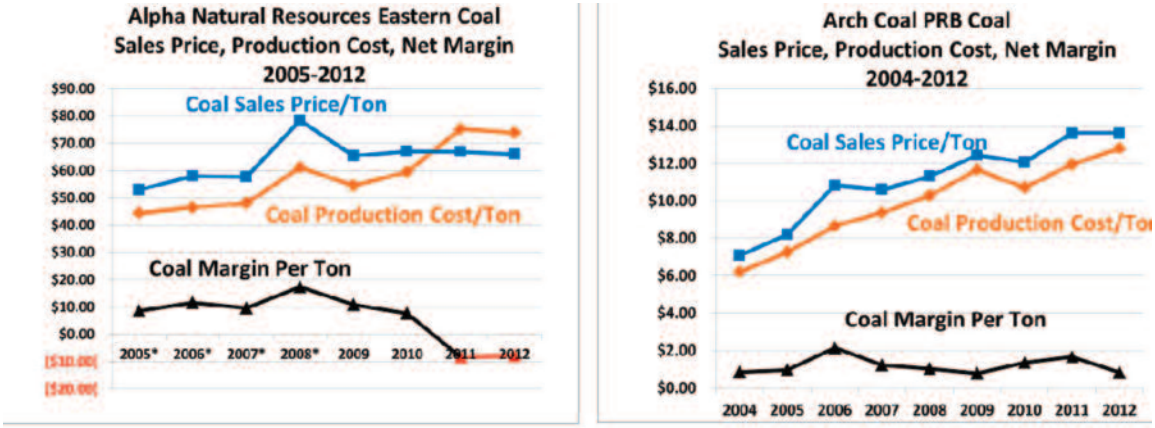
65 In the United States, the production cost for coal fell through the 1990s as the large surface mines of the Powder River Basin were opened. Using surface mining techniques to access the large coal seams in Wyoming and Montana led to much lower production costs than were being faced by the aging Appalachian mines, many of which were underground. The lower production costs for Wyoming were matched with increased transportation costs to carry the coal to distant coal plants. As the original pits for the Powder River Basin mines are depleting, the production costs for these mines also began to rise as shown in Figure 7 in the text above.

66 The largest US coal company is Peabody Energy ("BTU"). The second largest coal company (based on volume of coal sold) is Arch Coal Incorporated ("ACI") and the third largest US coal company (by volume) is Alpha Natural Resources ("ANR").

67 An analysis of rising coal production costs was published by SNL on April 10, 2013 with the key results shown here http://ohiocitizen.org/us-coal-producers-scrambling-in-face-of-skyrocketing-production-costs/

Figure 8: Impact of Rising Production Costs on Profit Margins for Eastern and Powder River Basin Coal Mines

(Data from Year End and 10-K Annual Reports for the indicated coal companies.)



As can be seen in Figure 8 above, the net margin for eastern coal mined by Alpha Natural Resources (the #3 US coal company) has been negative for 2011 and 2012. That is, the production cost (orange line) exceeded the sales price (blue line) for coal sold from Alpha Natural Resources' eastern mines. As explained in Part 5 below, this led to large reported losses for Alpha Natural Resources in 2012.

As can also be seen from Figure 8 above, the margin for coal mined in the Powder River Basin by Arch Coal is not very large—often less than $1/ton and for some quarters is negative—meaning that for every ton of coal that Arch mined, it lost money.[68] For the first 6 months of 2013, Arch Coal reported an operating margin of 49 cents/ton for its Powder River Basin mines.[69]

While many of the coal industry's woes have been attributed to the relatively low cost of natural gas in 2011 and 2012, the impact of rising coal production costs on the financial statements of the coal companies is starting to be noticed in various media stories.[70]

Table 4 below documents how coal mine productivity for the top two coal producing states, Wyoming and West Virginia, as well as the US average have declined steadily since the early years of the 21st century.

The significant drop in coal mine productivity since 2004 is shown in Figure 9 below.

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68 See http://investor.archcoal.com/phoenix.zhtml?c=107109&p=irol-newsArticle&id=1781384

69 See Arch 10-Q 2013 Q2 p29, available at http://investor.archcoal.com/phoenix.zhtml?c=107109&p=irol-sec

70 See for example: 1) http://www.washingtonpost.com/business/economy/cost-of-mining-coal-continues-to-climb/2012/10/24/d15666ca-1931-11e2-bd10-5ff056538b7c_story.html, http://grist.org/climate-energy/big-coal-in-big-trouble-as-coal-production-costs-rise/, and http://www.tnr.com/blog/plank/110067/what-was-romney-doing-in-coal-country# and http://newsok.com/in-decline-coal-in-crosshairs-in-va.-govs-race/article/feed/600292 , and http://www.coalage.com/index.php/features/2973-prb-operators-reduce-production-to-match-market-demand.html See also the report by SNL author Darren Epps on rising production costs for US coal companies issued on April 10, 2013 with summary here http://ohiocitizen.org/us-coal-producers-scrambling-in-face-of-skyrocketing-production-costs/

Table 4: Coal Mine Productivity Select Years 2000-2011

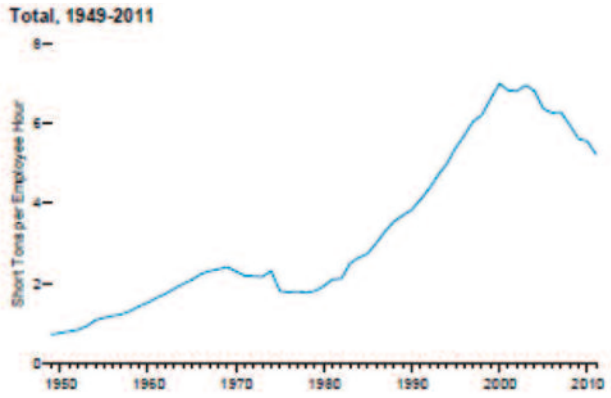
Average Production in Tons Per Employee Per Hour

Data typically from Table 21 in EIA Annual Coal Report http://www.eia.gov/coal/annual/

State or Region	2000	2004	2006	2008	2011
West Virginia	4.91 tons/hr	4.03 tons/hr	3.32 tons/hr	3.06 tons/hr	2.45 tons/hr
Wyoming	38.29 tons/hr	38.83 tons/hr	35.46 tons/hr	32.18 tons/hr	29.34 mtons/hr
US Average	6.99 tons/hr	6.80 tons/hr	6.26 tons/hr	5.96 tons/hr	5.19 mtons/hr

Figure 9: Coal Mine Productivity 1949-2011

Graph from Table 7.7, EIA Review http://www.eia.gov/totalenergy/data/annual/index.cfm#coal

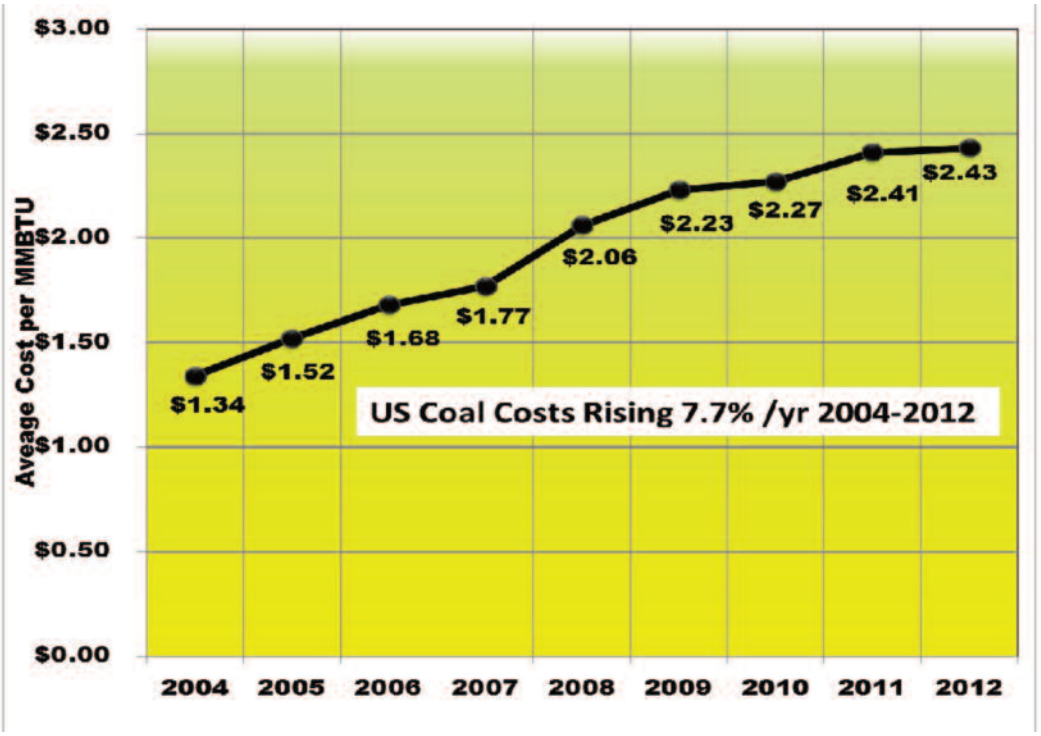


B. US Coal Costs Are Rising 2-3 Times Faster Than Inflation

Since 2004, US delivered coal costs to electric utilities[71] have been rising on average 7-8% per year—or about 2-3 times faster than inflation.[72] Costs that rise at a rate above 7%/year will double in less than a decade.[73] Rising coal costs reflect the rising costs of production for coal as it becomes increasingly difficult to access the remaining coal. In addition, increased transportation costs and export pressure are likely pushing coal costs up. These rising costs are shown in Figure 10 below and detailed in Table 5.[74]

Figure 10: US Coal Delivered Costs to Electric Utilities 2004-2012

Data from EIA Electric Power Monthly (usually Feb or March report for previous year.)
http://www.eia.gov/electricity/monthly/



71 This report focuses on thermal coal delivered to electric utilities. Prices for metallurgical coal used in steel making are volatile and discussed extensively by coal industry analysts as the price of metallurgical coal can have a large impact on the earnings of coal companies that mine metallurgical coal. The interested reader can simply search the internet for the latest on metallurgical coal prices.

72 US inflation rates can be tracked on line at http://www.usinflationcalculator.com/inflation/current-inflation-rates/

73 Doubling time can be approximated by dividing 70 by the rate of increase. See http://www.investopedia.com/terms/r/rule-of-70.asp

74 The Clean Energy Action report, "Trends in US coal costs from 2004-2012" presents coal costs for all states that report coal costs and discusses the reasons for the rising coal cost trends. The report is available from http://cleanenergyaction.org/research-reports/

Table 5: 2004 and 2012 Delivered Coal Costs—Selected States

Data for Electric Utilities from EIA Electric Power Monthly. Compound increase calculated from data shown.
http://www.eia.gov/electricity/monthly/

State	2004 Delivered Coal Costs $/MMBTU	2012 Delivered Coal Costs $/MMBTU	2004-2012 Compound % Increase/Year
Alabama	$1.51	$3.00	8.96%
Colorado	$0.97	$1.85	8.41%
Florida	$1.89	$3.49	7.97%
Georgia	$1.79	$3.47	8.63%
Illinois	$1.16	$2.08	7.57%
Indiana	$1.21	$2.60	10.03%
Iowa	$0.90	$1.48	6.41%
Kentucky	$1.39	$2.44	7.29%
Louisiana	$1.37	$2.87	9.68%
Maryland	$1.74	$3.62	9.59%
Michigan	$1.37	$2.92	9.92%
Minnesota	$1.06	$1.98	8.12%
Mississippi	$1.73	$4.45	12.54%
Missouri	$0.92	$1.86	9.2%
Montana	$0.63	$1.52	11.64%
New Jersey	$2.27	$4.05	7.50%
New Mexico	$1.48	$2.18	4.96%
New York	$1.58	$3.20	9.22%
Ohio	$1.32	$2.41	7.81%
Pennsylvania	$1.23	$2.46	9.05%
Virginia	$1.90	$3.61	8.35%
West Virginia	$1.41	$2.70	8.46%
Wisconsin	$1.16	$2.37	9.34%
Wyoming	$0.86	$1.44	6.65%
US Total	**$1.34**	**$2.43**	**7.72%**

An additional factor that could drive up coal costs is the brewing controversy over the practice of coal "leasing" in the western United States in which coal is often leased by the federal government for $1 per ton or less.[75] Many advocates have argued that this is not an accurate representation of "fair

75 See for example http://thinkprogress.org/climate/2012/06/29/508585/blm-auctions-720-million-ton-north-porcupine-coal-tract-to-single-bidder-for-110-a-ton/ and http://www.denverpost.com/ci_21376769/peabody-gets-lease-mine-coal-near-hayden-at (This article discusses a 2013 coal "lease" in Colorado in which the coal was "leased" for 25 cents a ton).

market value," and if future coal leases are granted at a higher cost, this could also increase the cost of coal delivered to US utilities.[76]

Another factor that could drive up coal costs is the need to improve reclamation success for the huge open-pit coal mines in the Powder River Basin of Wyoming and Montana. Typically less than one-third of the mines have been reclaimed[77] despite the requirement of the Surface Mine Control and Reclamation Act[78] that surface mines be reclaimed "contemporaneously."[79] If the large surface mines of Wyoming and Montana are required to reclaim more land, this will very likely increase the cost of producing coal and drive up coal costs for utilities and their customers.

On average, US delivered coal costs to electric utilities are going up over 7% per year. Even states with low coal costs are seeing coal costs increase over 6% per year. Many states have coal costs increasing over 8% per year. Delivered coal costs are increasing several times faster than inflation—a sign that coal is increasingly expensive to mine and transport.

C. The US Appears to Be Past Peak Coal Production

While it will take several more years to be certain, it appears that the United States may be past the peak of coal production on a volume basis with production having fallen off over 13% by the end of 2012 from the apparent production peak in 2008. Given the increasing reliance on lower heat content subbituminous coal,[80] the US is almost certainly past peak coal based on the heat content of the coal produced.[81]

As shown in Figure 11 below, US coal production appears to have reached a peak in 2008 with production of approximately 1.171 billion short tons. While it is possible that future US coal production will exceed the 2008 level, it does not appear likely given the geologic constraints facing US coal mines and the increasing cost needed to mine coal at a time when renewable energy resources are falling in price and concern about climate change is mounting.

76 See for example, "The Costly Giveaway: An Analysis of the Costly Failure of Federal Coal Leasing in the Powder River Basin," available from http://www.ieefa.org.php53-4.dfw1-2.websitetestlink.com/wp-content/uploads/2012/06/062512_IEEFA_PRB_coal_report_FINAL2.pdf

77 See for example the 2011 Office of Surface Mine Reclamation and Enforcement ("OSMRE") Annual Evaluation Reports for Wyoming and Montana available from http://odocs.osmre.gov/qdocs.aspx and http://www.wrcc.osmre.gov/programs/oversight/montana/evaluation/MontanaEvaluation.shtm

78 30 United States Code §1201 et seq.

79 See 30 U.S.C. §§1201-1328. Reclamation is to be as "contemporaneous as possible" under 30 U.S.C. § 1202(e)

80 Since 1980, the US has turned from mining predominantly higher heat content bituminous coal to mining lower heat content subbituminous coal, particularly from the Powder River Basin of Wyoming and Montana.

81 Given the increasing reliance of the US on lower heat content coals, it has been noted that the United States passed peak coal production on a heat content basis in the 1990s. See for example, page 30 in the 2007 Energy Watch Group report "Coal: Future Resources and Production," available at www.energywatchgroup.org/.../EWG_Report_Coal_10-07-2007ms.pdf

Figure 11: US Coal Production 2002-2012

Data from EIA Annual Coal Reports http://www.eia.gov/coal/data.cfm

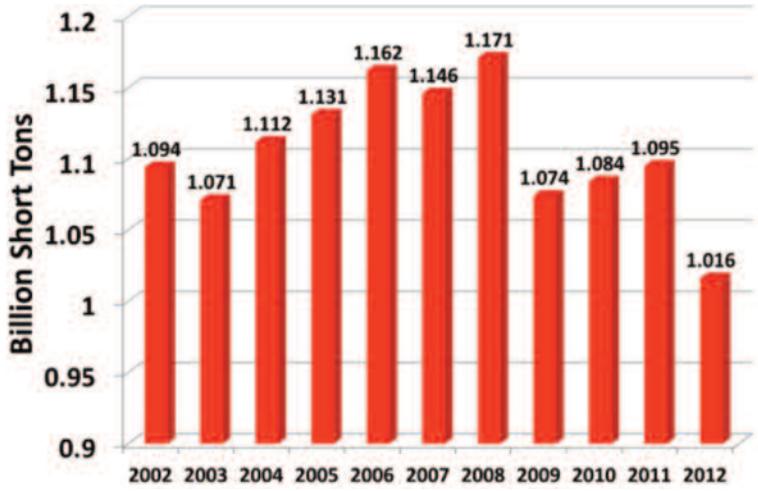


Table 6: Top 16 Coal-Producing States—All Past Peak?

(Data from EIA Annual and Quarterly Coal Reports available at http://www.eia.gov/coal/data.cfm and for peaks before 1990, from EIA State Coal Reports available at ftp://ftp.eia.doe.gov/coal/0576.pdf)

2012 Rank	US Coal Producing State	Apparent Peak Year	Production in Peak Year (Million Tons[82])	Production in 2012[83] (Million Tons)	Approximate Percent Reduction in 2012 Production from Peak
#1	Wyoming	2008	467.6	401.4	-14.2%
#2	West Virginia	1947[84]	176.2	120.1	-31.8%
#3	Kentucky	1990[85]	173.3	90.6	-47.7%
#4	Pennsylvania	1918[86]	277.4	55.0	-80.2%
#5	Illinois	1918[87]	89.3	47.9	-46.4%
#6	Texas	1990[88]	55.8	44.2	-20.8%

continued on p.34

82 Production numbers provided as million short tons.

83 2012 Production numbers are preliminary numbers from the EIA 2012 Q4 Quarterly Coal Report available from http://www.eia.gov/coal/production/quarterly/ .

84 See EIA State Profile Coal Reports for West Virginia available at ftp://ftp.eia.doe.gov/coal/0576.pdf, page 105

85 See EIA State Profile Coal Reports for Indiana available at ftp://ftp.eia.doe.gov/coal/0576.pdf, page 45

86 See EIA State Profile Coal Reports for Pennsylvania available at ftp://ftp.eia.doe.gov/coal/0576.pdf, page 81

87 See EIA State Profile Coal Reports for Illinois available at ftp://ftp.eia.doe.gov/coal/0576.pdf, page 28

88 See EIA State Profile Coal Reports for Texas available at ftp://ftp.eia.doe.gov/coal/0576.pdf, page 88

Table 6: Top 16 Coal-Producing States—All Past Peak? continued

(Data from EIA Annual and Quarterly Coal Reports available at http://www.eia.gov/coal/data.cfm and for peaks before 1990, from EIA State Coal Reports available at ftp://ftp.eia.doe.gov/coal/0576.pdf)

2012 Rank	US Coal Producing State	Apparent Peak Year	Production in Peak Year (Million Tons[82])	Production in 2012[83] (Million Tons)	Approximate Percent Reduction in 2012 Production from Peak
#7	Montana	2008	44.8	36.7	-18.1%
#8	Indiana	1984[89]	37.6	36.7	-2.4%
#9	Colorado	2004	39.9	28.6	-28.3%
#10	Ohio	1970[90]	55.4	27.6	-50.2%
#11	North Dakota	1994	32.3	27.5	-14.9%
#12	New Mexico	2001	29.6	22.4	-24.3%
#13	Alabama	1990	29.0	19.6	-32.4%
#14	Virginia	1990	46.9	18.1	-61.4%
#15	Utah	2001	27.0	16.4	-39.3%
#16	Arizona	2001	13.4	7.5	-44.0%

From Table 6 above, it can be seen that coal production in 2012 by the top 16 states[91] was lower than their peak coal production, and in most states significantly lower—indicating that essentially all major US coal producing states are likely past their peak in production.[92]

It will take a few more years to see whether the 2012 decline in coal production is anomalous,[93] but given the geologic constraints facing US coal mines, it is questionable whether US coal production will rise higher than the 2008 peak shown in Figure 11 above.

D. Coal Production in the Powder River Basin of Wyoming and Montana Appears to Be Past Peak

As production of bituminous coal from mines in the Appalachia states (e.g. West Virginia, Kentucky, Pennsylvania and Virginia) and in the Western bituminous region (e.g. Colorado, New Mexico, Utah and Arizona) has fallen, a large number of mid-western, Great Plains and western states have turned to the subbituminous coal produced in the Powder River Basin of Wyoming and Montana. From Table 6 above, it can be seen that Wyoming

89 See EIA State Profile Coal Reports for Indiana available at ftp://ftp.eia.doe.gov/coal/0576.pdf page 32

90 See EIA State Profile Coal Reports for Ohio available at ftp://ftp.eia.doe.gov/coal/0576.pdf page 70

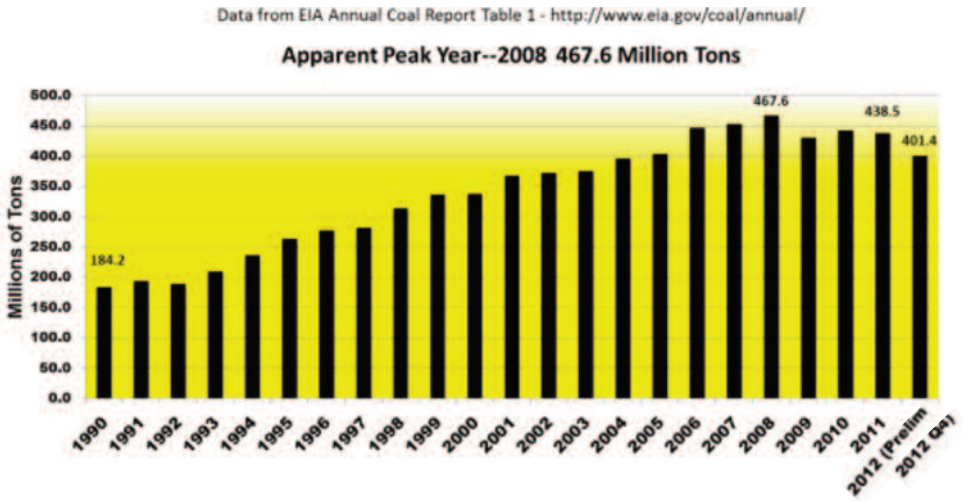
91 Coal production in the top 16 states in 2012 totaled over 1 billion tons or over 98% of total US production for that year.

92 It is possible that Indiana will surpass its 1984 peak due to the increased use of high sulfur coal after the installation of sulfur controls on US coal plants. This will not likely have a significant impact on the overall US peak given that Indiana produces less than 4% of US coal.

93 Coal production in 2012 was possibly driven lower by natural gas prices that led a number of utilities to decrease their reliance on coal and increase their reliance on natural gas. This led to large coal stockpiles that depressed 2012, and possibly 2013, production. See also http://www.coalage.com/index.php/features/2973-prb-operators-reduce-production-to-match-market-demand.html

provides approximately 40% of the coal produced in the United States and from Figure 12 below, it can be seen that Wyoming coal production has fallen off about 14% from the apparent peak in 2008.

Figure 12: Wyoming Coal Production 1990-2012



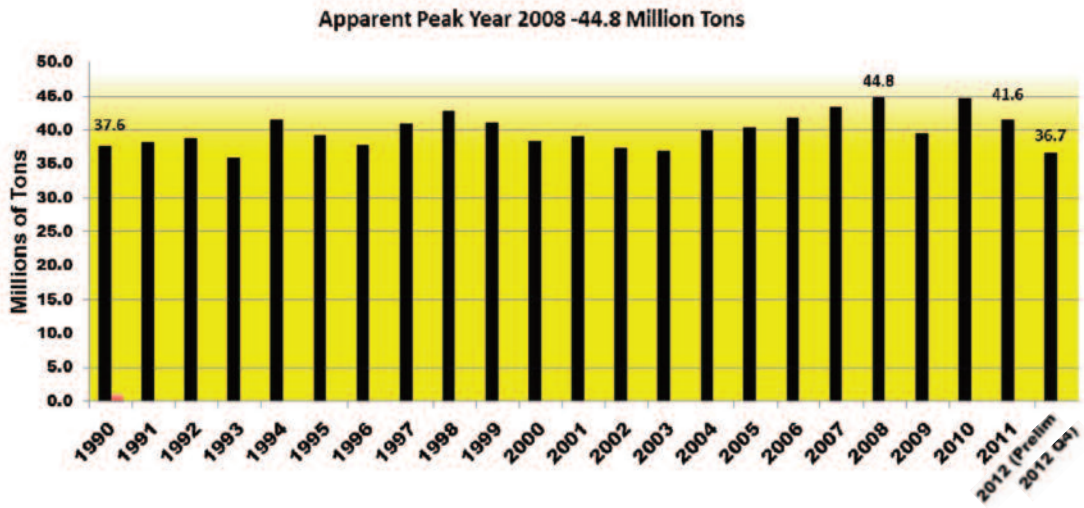
As shown previously in Table 3, the large Wyoming mines can expand their existing pits into areas where the coal has been recently or will be "leased" from the federal government,[94] but the coal in these expansion areas will be buried significantly deeper than the coal that has been mined from the existing pits in the last several decades. Coal that is buried more deeply is generally more expensive to mine[95] and prices must either rise to match the increased production cost or the profit margins of the coal mining companies will be diminished or can even become negative as shown in Figure 8.

As seen in Figure 13 below, coal production in Montana is only about one-tenth of coal production in Wyoming and has also fallen about 18% since the apparent peak in 2008. No one can predict the future, but it seems unlikely that coal production in Montana will increase significantly given the strong opposition to opening new coal mines and related infrastructure.

94 To see the details of the coal "leases" administered by the US Bureau of Land Management, see the footnotes accompanying Table 3.

95 See for example http://www.prnewswire.com/news-releases/powder-river-basin-price-spike-ahead-223892981.html

Figure 13: Montana Coal Production 1990-2012



While many Americans assume that there is still a lot of easily accessible coal in the western US, given likely geologic, financial and legal constraints, it is not clear how much of this coal can be mined at a profit.

E. US Coal Reserves Have Been Questioned in the Academic Literature

In addition to extensive data analyses by the United States Geological Survey on US coal resources and reserves discussed in Part 2, there is a growing body of literature from academic and industry sources questioning the idea that the United States has a "200 year" supply of coal including the following examples of reports and academic papers.[96]

2007—Energy Watch Group[97]

In 2007, German researchers prepared the "Energy Watch Group" report which sounded a clear call to take a harder look at reporting of coal "reserve" data around the world. The EWG report noted (page 4) that "data quality of coal reserves and resources is poor, both on global and national levels." They also noted that US coal production likely peaked on an energy content basis in 1998 (page 30) , that several countries have significantly reduced their reported supplies of coal reserves (pages 4-5) and that US coal reserve estimates may be "highly exaggerated" (page 35).

2009—Hook and Aleklett[98]

In 2009, two researchers from Uppsala University in Sweden did a detailed analysis of US reports of

96 The author apologizes for all omissions. This section is not meant to be an exhaustive scientific literature search, but rather just an introduction to the literature questioning coal reserve reporting. In addition to the articles and reports discussed in this section, the reader is referred to two books—Big Coal, by Jeff Goodell (Houghton Mifflin, 2006), pages 4-20 and Blackout: Coal, Climate and the Last Energy Crisis, by Richard Heinberg (New Society Publishers, 2009) pages 35-53, which both discuss US coal reserve reporting though neither book looks carefully at the existing economic and financial data for the US coal industry.

97 Energy Watch Group 2007 coal report available from http://www.energywatchgroup.org/fileadmin/global/pdf/EWG_Report_Coal_10-07-2007ms.pdf

98 "Historical trends in American coal production and a possible future outlook" Mikael Höök, Kjell Aleklett, published in International Journal of Coal Geology 78:201 (2009) available from http://www.sciencedirect.com/science/article/pii/S0166516209000317

coal reserves and noted that reserve estimates of US recoverable reserves have been constantly reduced over the decades (page 212) and that "The amount [of coal] that actually can be recovered is far less than all the coal that is geologically available and this distinction should always be noted." (page 212).[99]

2009—Mohr and Evans[100]

In 2009, two Australian researchers developed a model for predicting mineral resource production and applied it to all coal producing countries. The authors concluded, "The model projects that worldwide coal production will peak between 2010 and 2048 on a tonnage basis, and between 2011 and 2047 on an energy basis. The notion that coal is widely abundant therefore appears to be unjustified." Mohr and Evans noted that," The large range in peak year estimates cannot be narrowed until reliable URR [ultimately recoverable reserves] estimates are available."

2010—Patzek and Croft[101]

In 2010, two researchers from University of Texas-Austin and University of California Berkeley, published a mathematical "multi-Hubbert" analysis of historical global coal production data and predicted that "The global peak of coal production from existing coal fields is predicted to occur close to the year 2011." For the United States, Patzek and Croft predicted a peak production year of 2015. The authors note (in Footnote 5) that if they are right about the peak in coal production "prudent policy makers ought to perhaps consider it" as it will require "major restructuring…."[102]

2011—Rutledge

In 2011, Caltech Professor David Rutledge published a mathematical analysis of coal production entitled, "Estimating Long-Term Coal Production with Logit and Probit Transforms."[103] The results of Professor Rutledge's analysis are presented in Part1 above and in Part 4 below. Professor Rutledge argues that estimating total coal production from early estimates of coal "reserves" is generally inaccurate and total coal production has often been historically only 20-40% of the original estimate of coal "reserves."[104]

2012—Grubert[105]

In 2012, University of Texas-Austin researcher Emily Grubert published a detailed discussion of the confusion surrounding estimates of US coal "reserves" and warned that inaccurate information can lead to "inefficient allocation of limited capital investment that can be difficult to reverse." Grubert notes that typically less than 25% of coal resources will actually be "reserves" which can be recovered profitably and emphasizes the need to update EIA reports of coal "reserves" as they are based on data that is "both very old and based on outdated methodology."

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99 Hook and Aleklett recognized the likely problems with US coal reserve reporting but based their primary projection on EIA's Estimated Recoverable Reserve number suggesting a peak in US coal production in 2030 (assuming that Montana coal production does not greatly increase)—but did not seem to understand that EIA's Estimated Recoverable Reserves have not been analyzed for economic recoverability as discussed in Part 1.

100 "Forecasting coal production until 2100," Mohr, S.H. and Evans, G.M., Fuel 88:2059 (2009) available from https://www.sciencedirect.com/science/journal/00162361/88/11

101 "A global coal production forecast with multi-Hubbert cycle analysis," Patzek, T and Croft, G. published in Energy 35: 3109 (2010) found at http://www.sciencedirect.com/science/article/pii/S0166516209000317

102 "A global coal production forecast with multi-Hubbert cycle analysis," Patzek, T and Croft, G. available from http://www.sciencedirect.com/science/article/pii/S0360544210000617, Footnote 5, page 3110.

103 See http://www.its.caltech.edu/~rutledge/DavidRutledgeCoalGeology.pdf

104 In addition, one of the points being made in this report is that in the 21st century, declining cost renewable energy has the potential to foreshorten actual coal production even further.

105 "Reserve reporting in the United States coal industry," Emily Grubert Energy Policy (2012) available from http://www.sciencedirect.com/science/article/pii/S0301421512000614

2013—Stanton (NRRI)[106]

In 2013, National Regulatory Research Institute researcher Tom Stanton wrote a heavily-referenced paper on challenges facing coal-dependent utilities and included an extended discussion of US coal reserves. The NRRI paper noted that decision makers could be misinformed "by an incomplete picture of future coal availability and price" which could lead to faulty analysis and imprudent investments.

2013—Millici, Flores, Stricker

In mid-2013, a group of USGS researchers published a paper calling for better assessment of US coal reserves.[107] The authors recognize that a very large percentage of US coal comes from large-scale mines (mega mines) in the Powder River Basin and that the future of these mines is uncertain. The authors note that in order to maintain US coal production either existing mines will have to increase their recoverable reserves and/or new large-scale mines will have to be opened elsewhere. The authors note that much of the basic data on coal resources is outdated and call for probabilistic assessments of remaining coal deposits to improve long-range forecasts of coal production. The authors seem to recognize that the "ERR of EIA is subject to considerable uncertainty,"[108] but the authors do not seem to be aware of the likely peak in US coal production in 2008 or of financial and geologic constraints facing the current mega-mines and the companies that own them.[109]

It is interesting to note that recent trends at the giant Black Thunder mine in Wyoming underscore the concerns of the Millici paper about a large percentage of US coal coming from a few "mega mines." Production from what was the largest US coal mine, the Black Thunder, dropped 20% from 116.2 million tons in 2010 to 92.9 million short tons in 2012, according to financial filings of Arch Coal Inc., the owner of the Black Thunder.[110]

A growing number of academic and industry researchers are calling into question the reporting of US coal reserves and the accuracy of claims of a "200 year" supply of US coal.

106 See "Understanding Peak Coal," by Tom Stanton, NRRI http://www.nrri.org/documents/317330/534f7c48-d67f-4ede-b22f-3d043fe6545f

107 See "Coal resources, reserves and peak coal production in the United States," by Robert Millici, Romeo M. Flores and Gary D. Stricker, International Journal of Coal Geology 113(2013) 109-115 available for purchase from https://www.sciencedirect.com/science/article/pii/S016651621200242X

108 See Millici, page 112 available at https://www.sciencedirect.com/science/article/pii/S016651621200242X

109 The data provided in the Millici paper appears to be outdated and inaccurate. On page 111, the authors state that US coal production in 2009 was 1,084,368,148 (or 1.084 billion) short tons of coal. This is the number that EIA reports for 2010 US coal production, not 2009 as stated by the authors of the Millici paper. EIA reported 2009 US coal production as 1.074 billion short tons. (Refer to the EIA Annual Coal Reports available from http://www.eia.gov/coal/annual/) In Table 3 of the Millici paper, the authors provide what they refers to as 2009 production data, but state that the Black Thunder mine produced 116.2 million short tons. That is incorrect. In 2009, the Black Thunder mine produced 81 million short tons. Then in 2010, the Black Thunder combined with the Jacobs Ranch for its apparent peak year 2010 production of 116.2 million short tons. (See EIA Annual Coal Report, Table 9 available from http://www.eia.gov/coal/annual/) Coal mine production in Table 3 of the Millici report appears to be 2009 production for all other mines but for reasons that are unclear, Table 3 provides 2010 production for the Black Thunder. To further confuse matters, Table 3 reports what is described as 2009 production for the combined Black Thunder and Jacobs Ranch mines as 116.2 million tons, but from the 2009 EIA Annual Coal Report Table 9, the combined 2009 production for the Black Thunder and Jacobs Ranch mines was 110.1 million tons. The important truth is that production for the Black Thunder peaked in 2010 at 116.2 million tons and had dropped to 92.9 million tons in 2012, a drop of 20% in 2 years.

110 See Arch Coal 2012 Annual 10-K report, page 13 available from http://investor.archcoal.com/phoenix.zhtml?c=107109&p=irol-reportsAnnual

Part 4: Cautionary Tales—Non-Renewable Resources Really, Truly DO NOT Renew

A. Cautionary Tales (Part I); The Decline of Britain's Coal Industry and Other Lessons from "Mature" Coal Regions

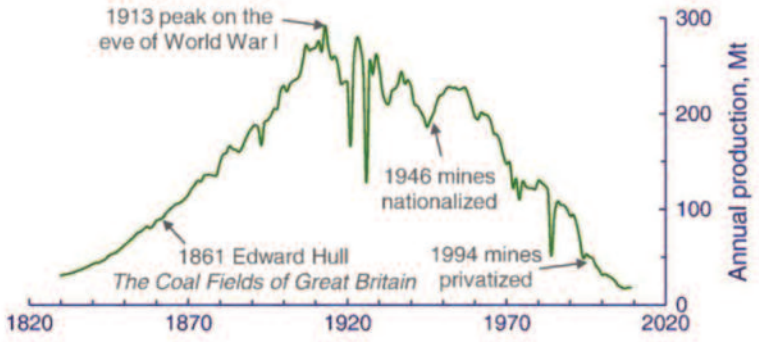
As detailed by Professor David Rutledge[111] of the California Institute of Technology, Britain and other "mature" coal fields can serve as important cautionary tales for the United States, underscoring the following:

- By definition, non-renewable resources do not renew and when the easily accessible deposits have been mined, the mines will close and production from that coal field will drop.
- Early estimates of coal production are often based on overly optimistic criteria for reserves and have often been too high—often significantly too high.
- Coal deposits that were originally counted as "reserves" are often converted to "resources." These deeply buried coal "resources" are not likely to be economically mined and often could better be referred to as "occurrences."

As presented by Professor Rutledge, Britain's coal production has followed the trajectory shown in Figure 14 below.

Figure 14: Britain's Coal Production 1820-2010

From http://www.its.caltech.edu/~rutledge/DavidRutledgeCoalGeology.pdf



111 "Estimating long-term world coal production with logit and probit transforms," David Rutledge, International Journal of Coal Geology 85, 23–33(2011), available from http://www.sciencedirect.com/science/journal/01665162/85/1 or directly from Professor Rutledge at http://www.its.caltech.edu/~rutledge/DavidRutledgeCoalGeology.pdf , cited as "Rutledge, 2011."

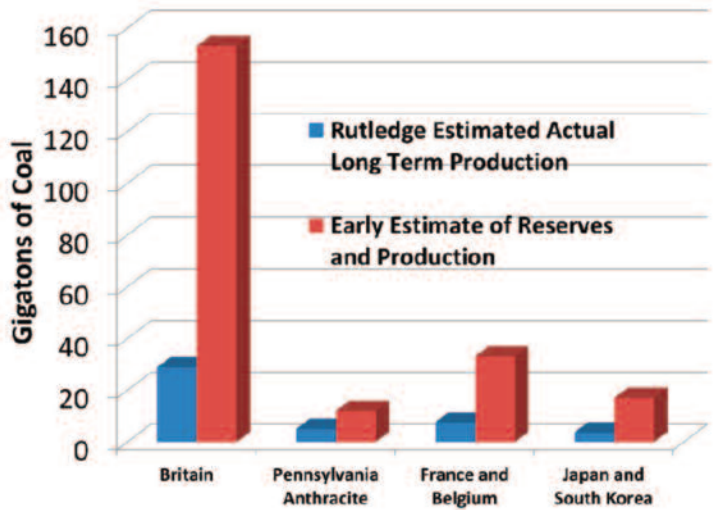
In analyzing Britain's coal production, Professor Rutledge quotes from the 1861 British geologist Edward Hull and notes that in 1861 Hull predicted that British coal supplies would last for "no less than 1,100 years." As shown in Figure 14 above and described by Rutledge below, Hull's estimate of over 1,000 years of British coal was wildly inaccurate.

> Thus we now know the answer to the question Edward Hull posed in 1861. British coal has lasted 150 years, not 1100 years. British mines have produced 27 Gt of coal, not Hull's 81 Gt nor the Royal Commission's 149 Gt. In retrospect, it is clear that both Hull's numbers and the Royal Commission's were not good estimates of production in the long run. It is also clear what was wrong with the estimates – the criteria were too optimistic. (Rutledge 2011, page 24)

Professor Rutledge proceeded to analyze production in several other "mature" coal fields (i.e. current production is less than 10% of peak production) and noted that long-term production is consistently lower than early estimates based on "reserve" numbers.

Figure 15 : Long Term Coal Production Often a Small Fraction of Early Estimates Based on Coal "Reserve" Estimates

Data from http://www.its.caltech.edu/~rutledge/DavidRutledgeCoalGeology.pdf



Mature coal regions serve as cautionary tales that actual coal production is often much less than estimates of coal production based on "reserve" estimates; similarly, it is highly unlikely that the US has "200 years" of coal reserves.

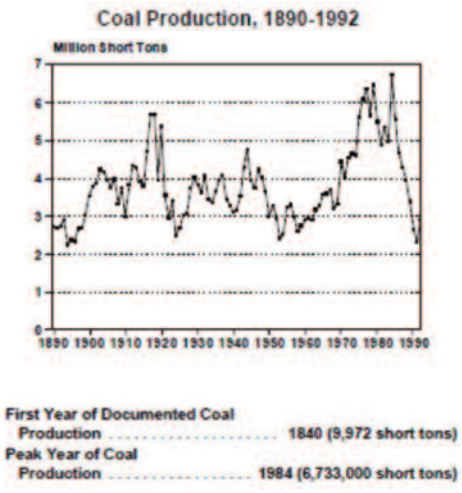
B. Cautionary Tales (Part II); US Workers, Communities and States Need to Prepare for When Coal Mines Play Out

In addition to the history of coal production in Britain and other mature coal regions as shown in Figures 15, the coal production history for various states can serve as a "cautionary tale" for states that are currently heavily dependent on coal mining. When coal mines play out, then the jobs, taxes and economic benefits associated with the coal mines also go away and plans need to be made for the workers, communities, counties and states that had become reliant on the coal industry for the associated taxes and economic activity.

As shown in Figure 16 below, states like Missouri and Oklahoma used to mine significant amounts of coal, but now they are well past peak and only producing a million tons of coal a year or less. These states have had to adjust to the loss of most of their coal industry.

Figure 16: Examples of States That Peaked in Coal Production in the Late 20th Century and Which Have Lost Most of Their Coal Production

Missouri			Oklahoma		
Peak Coal Production	1984	6.7 mtons[112]	Peak Coal Production	1978	6.1 mtons[113]
Coal Production	2012	0.42 mtons[114]	Coal Production	2012	1.05 mtons[115]



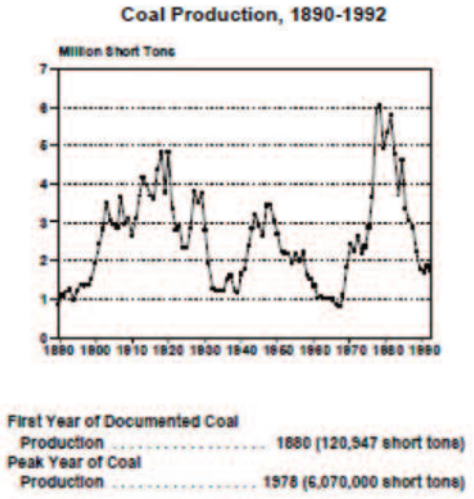


Figure 16 above shows two examples of states (Mississippi and Oklahoma) that in the last half of the 20th century still had significant coal industries in their states but which have had to adjust to the loss of most of their coal production. Many other states will likely be in a similar position in the coming years.

Figure 17 below shows examples of two states—Iowa and Washington—which produced significant amounts of coal in the 20th century but which in 2012 reported no coal production.

112 Missouri historical coal production from EIA State Coal Profiles ftp://ftp.eia.doe.gov/coal/0576.pdf, page 56

113 Oklahoma historical production from EIA State Coal Profiles ftp://ftp.eia.doe.gov/coal/0576.pdf, page 76

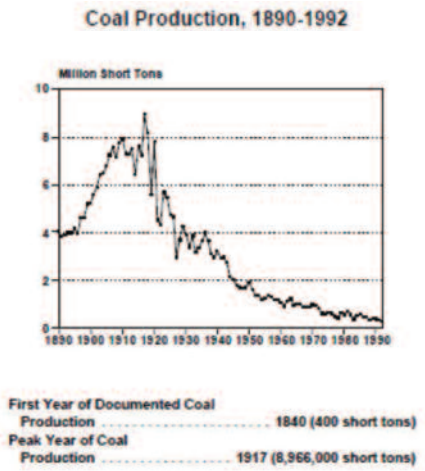
114 Coal production for 2012 from EIA Quarterly Report Q4 from http://www.eia.gov/coal/production/quarterly/

115 Coal production for 2012 from EIA Quarterly Report Q4 from http://www.eia.gov/coal/production/quarterly/

Figure 17: Examples of States That Have Lost All of Their Coal Production

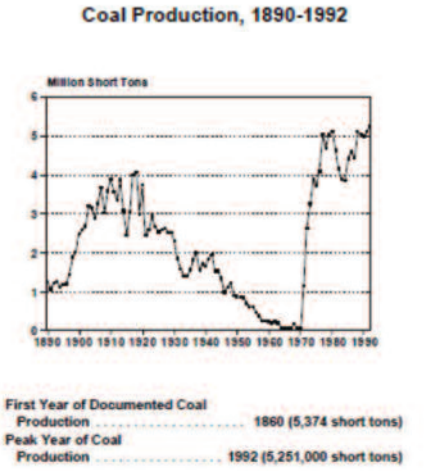
Iowa

Peak Coal Production	1917	8.6 mtons[116]
Coal Production	2012	None[118]



Washington

Peak Coal Production	1982	5.2 mtons[117]
Coal Production	2012	None[119]



Several US states that used to produce coal, produced little or no coal in 2012. These states have had to adjust to the loss of coal mining jobs, tax revenues and economic benefits. States that are currently dependent on coal should begin planning for when their coal mines play out.

C. Ignorance About Coal Cost and Supply Issues Leads to Complacency—and Misplaced Investments

Due in part to the widely held belief that the United States has a "200 year" supply of coal, large investments are made in coal without a careful assessment of coal cost and supply issues. This has led to very large investments in coal plants of hundreds of millions of dollars—or sometimes even in the billions—that have either been lost or are likely to become stranded.

Electric utility leaders and their consultants appear to be generally unaware of US coal cost and supply issues and are not giving careful consideration to potential coal supply constraints. For example, Figure 18 below shows the results of the Black and Veatch survey of electric utility personnel for their 2013 Strategic Directions in the US Electric Industry Report. Remarkably, coal cost and supply issues are not found in the top 10 list of concerns.

116 Iowa historical coal production from EIA State Coal Profiles at ftp://ftp.eia.doe.gov/coal/0576.pdf, page 36

117 Washington historical coal production from EIA State Coal Profiles at ftp://ftp.eia.doe.gov/coal/0576.pdf, page 101. Note that in 1994, coal was referred to as "an important part of the mineral economy of Washington." ftp://ftp.eia.doe.gov/coal/0576.pdf, page 99. In 2012, there was no coal production reported for Washington.

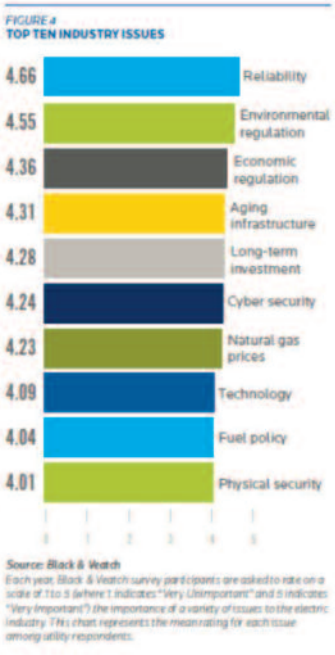
118 Coal production for 2012 from EIA Quarterly Report Q4 from http://www.eia.gov/coal/production/quarterly/

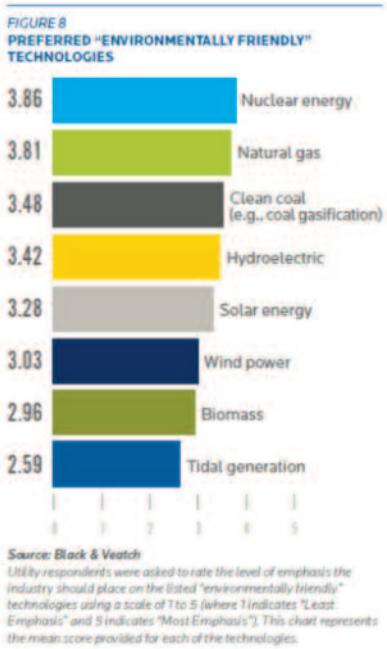
119 Coal production for 2012 from EIA Quarterly Report Q4 from http://www.eia.gov/coal/production/quarterly/

Figure 18: Electric Utility Industry Views on Key Issues

Black & Veatch's 2013 Strategic Directions in the US Electric Industry[120]

(Figure 4 from page 8. Figure 8 from page 12.)





It is hard to understand why "Clean Coal," (i.e. coal gasification) is ranked third in the list of 'Preferred 'Environmentally Friendly' Technologies" shown in Figure 18 above since the only two coal gasification plants moving forward in the United States are both seeing significant cost over-runs and accompanying write-offs by the responsible utility.[121] Moreover, as described throughout this report, it is not clear that any coal plant will have a reasonably-priced supply of coal for the 50 to 60 years that new coal plants are expected to operate for[122] or even for the 30-40 years that utilities hope to keep old coal plants operating after retrofits.[123]

Other examples of large investments in coal that have led to losses or run a significant risk of becoming stranded include:

- AES Eastern lost several hundred million when two New York coal plants went bankrupt and were sold to bond holders for $240 million while their original cost was approximately

120 Black and Veatch 2013 Strategic Directions in the U.S. Electric Utility Industry Report available at http://bv.com/reports/2013-electric-utility-report/

121 The Edwardsport, Indiana coal gasification (or "IGCC") plant has cost Duke $900 million in costs that won't be recovered from ratepayers and has a currently-estimated total cost of $3.5 billion (See http://fox59.com/2012/12/28/duke-energy-to-pay-900m-in-overrun-costs-at-edwardsport-coal-plant/#axzz2T74idDsa). The Kemper, Mississippi coal gasification plant has cost Mississippi Power close to a $1 billion in costs that won't be recovered and has a currently-estimated total cost of close to $5 billion (while recoverable costs are capped at $2.88 billion). In addition, $133 million in tax incentives will need to be repaid because the plant willll not be operational by May 2014. (See http://blog.powermag.com/index.php/2013/04/25/kemper-cost-rises-for-southern-company/ and http://www.pennenergy.com/articles/pennenergy/2013/10/kemper-coal-fueled-igcc-plant-delayed-missing-tax-break.html). In both cases, top utility executives have been removed due to IGCC issues.

122 Again, the confusion about US coal supplies can be traced to an inaccurate use of the term "reserves" on government websites including the National Energy Technology (NETL) program promoting "clean coal" with inaccurate portrayals of US coal "reserves" See http://www.netl.doe.gov/KeyIssues/secure_energy2a.html

123 For investments in old coal plants see http://www.power-eng.com/coal/coal-retrofits-upgrades.html

$550 million.[124] This followed the filing for bankruptcy of AES Thames and the closing of its coal plant in Montville, Connecticut.[125]

- The acknowledgement of legendary investor Warren Buffett that investing $2 billion in the heavily coal-dependent Texas-based Energy Future Holdings[126] was "a mistake – a *big* mistake." Berkshire Hathaway (Mr. Buffett's investment firm) has already written off over $1.3 billion of the investment and the firm could face "further loss."[127]
- The decision by First Energy to idle the huge Sammis coal plant in Ohio after investing over $1.8 billion in pollution upgrades,[128] as well as the Hatfield's Ferry plant in Pennsylvania after investing hundreds of millions of dollars in pollution controls.[129]
- The decision by Xcel Energy in Colorado to invest over $1 billion in the Pueblo coal plants without first assessing long term coal supplies.[130] Xcel's CEO at the time appeared to believe that the US had "200, 300 or 400 years' worth of coal."[131]
- The decision by Energy Capital Partners to close the 1500 MW Brayton Point coal plant in Massachusetts[132] despite a recent investment of over $1 billion on upgrades.[133]

Large amounts of money have been lost or put at risk by imprudent investments that have not considered long term coal cost and supply issues. Before investing in new or old coal plants, regulators and utility executives should not assume that the US has a 200 year supply of "cheap" coal.

124 See for example http://www.law360.com/articles/329083/bondholders-scoop-up-aes-eastern-power-plants-for-240m and http://www.powermag.com/aes-new-york-subsidiary-declares-bankruptcy-on-coal-woes/

125 See http://www.theday.com/article/20110204/BIZ02/302049988

126 Energy Future Holdings resulted from the leveraged buyout of TXU.

127 For Warren Buffett's description of the investment in Energy Future Holdings as a mistake and the over $1.3 billion in losses see http://www.berkshirehathaway.com/letters/2011ltr.pdf

128 For the idling of the Sammis coal plant after the addition of $1.8 billion in pollution controls, see http://online.wsj.com/article/SB10000872396390443696604577645713658834228.html

129 See http://wtrf.membercenter.worldnow.com/story/22794765/firstenergy-hatfields-ferry-similar-to-harrison-but-too-expensive-to-run

130 For the fact that Xcel built the Comanche 3 coal plant in Pueblo, Colorado without first assessing long term coal supplies, see Discovery Response LWG 5-11, dated April 18, 2008 found as Attachment 48 to the Answer Testimony of Leslie Glustrom in Docket 07A-447E, Colorado PUC.

131 For the interview with Xcel CEO Dick Kelly see http://www.cobizmag.com/articles/cotes-colorado .

132 Reporting of coal costs by Massachusetts to the EIA is very spotty and so their coal costs are not easy to track, but as with most northeastern states, were likely quite high. Delivered coal costs reported for 2010 were $3.19/MMBTU as reported in Table 4.10B, EIA Electric Power Monthly, February 2012, found at http://www.eia.gov/electricity/monthly/

133 See http://www.masslive.com/news/index.ssf/2013/10/brayton_point_power_station_in.html and https://www.dom.com/about/stations/fossil/brayton-point-power-station.jsp

PART 5:
Top US Coal Companies Are Largely Undiversified and in Serious Financial Distress

A. Top US Coal Companies Are Reporting Large Losses

The top three US coal companies, Peabody Energy ("BTU"), Arch Coal ("ACI") and Alpha Natural Resources ("ANR")[134] account for over 40% of US coal production. These coal companies are almost completely undiversified with almost all of their revenues tied to the production of coal. As the US reaches the end of easily recoverable coal and the cost of competing resources falls, the financial condition of the top US coal companies can be expected to decline—and it has.

As discussed in Part 3, the cost to produce coal has generally been rising as coal companies have to mine coal that is increasingly difficult to mine. This rise in production costs is often greater than the rise in sales price for the coal, narrowing profit margins. In addition, competition from "cheap" natural gas produced from shale gas as well as the declining cost of renewable energy have all combined to lead to difficult financial times for US coal companies.

In 2012, the top three coal companies all reported large losses.

- **#1—Peabody** reported just over **$1 billion in losses** in the fourth quarter of 2012 and **$585 million in losses** for the year, driving their Adjusted Earnings Per Share down from $3.77 in 2011 to $0.84 per share in 2012.[135]

- **#2—Arch Coal Inc.** reported **$295 million in losses** in the fourth quarter of 2012 and **$684 million in losses** for the year driving their Adjusted Earnings Per Share down from $1.07 in 2011 **to a loss per share of $0.36** in 2012.[136] In addition, Arch reported a **$115.8 million goodwill impairment charge** for its largest coal mine—the Black Thunder mine in Wyoming,[137] which it reported as follows:[138]

  > Based on initial estimates of the fair values of the assets and liabilities and the deficit of the fair value when compared to the related book values, the Company recorded a preliminary impairment charge for the entire $115.8 million carrying value of Black Thunder's goodwill during the second quarter of 2012. We subsequently performed a valuation of Black Thunder's assets and liabilities to determine the fair value of the reporting unit's goodwill, **which supported the estimation that the goodwill allocated to the Black Thunder reporting unit had no value.** (Page F-22, Arch Coal Inc. 2012 10-K. Emphasis added.)

- **#3—Alpha Natural Resources** reported serious losses in 2012 which they reported as follows:[139]

  > For 2012, Alpha recorded **a net loss of $2.4 billion, or $11.06 per diluted**

134 For a list of top coal producers, see Table 10 in the Energy Information Administration's Annual Coal Report available from http://www.eia.gov/coal/annual/pdf/table10.pdf

135 See Peabody's 2012 Year End Report (page 8) issued January 29, 2013, available from http://www.peabodyenergy.com/content/128/Financial-Information/Quarterly-Results

136 See Arch Coal Inc 2012 Fourth Quarter and Full Year report available from http://investor.archcoal.com/phoenix.zhtml?c=107109&p=quarterlyearnings

137 In 2012, Arch Coal sold 92.9 million tons of coal from the Black Thunder mine or about 69% of Arch's total $134.4 million tons sold. See page 14 Arch Coal Inc 2012 10-K report available from http://investor.archcoal.com/phoenix.zhtml?c=107109&p=irol-sec

138 See page F-22 in Arch Coal Inc 2012 http://investor.archcoal.com/phoenix.zhtml?c=107109&p=irol-sec

139 See Alpha Natural Resources 2012 Fourth Quarter and Year End report available from http://alnr.client.shareholder.com/results.cfm .

share. Excluding various items detailed in the attached "Reconciliation of Adjusted Net Income (Loss) to Net Loss", **the adjusted net loss in 2012 was $207 million, or $0.94 per diluted share**. EBITDA for 2012 **was a loss of $1.8 billion** and adjusted EBITDA, which excludes goodwill impairment and restructuring charges and various other items detailed in the "Reconciliation of EBITDA and Adjusted EBITDA to **Net Loss," was $792 million.**

As can be seen from the 2012 year end losses summarized above, it is clear that the major US coal companies are facing serious financial challenges. These losses have often been attributed to "low" natural gas costs in 2012,[140] but that is not the whole story.

As can be seen from Table 5, the average cost of delivered coal in the US in 2004 was $1.34/MMBTU while in 2012 the average cost of delivered coal had risen to $2.43—a price that made it much harder to compete with natural gas costs. The consequences of rising production costs for coal are discussed in Part 3. Beginning in late 2012, the impact of rising coal production costs on the financial statements of the coal companies began to be noticed by the national media and industry analysts.[141]

B. Top US Coal Companies Have Lost Most of Their Stock Value

The overall decline in the value of coal stocks over the last five years can be seen in Figure 19-21 showing the stock price from October 2007 to October 2012 for Peabody Energy ("BTU"), Arch Coal Inc ("ACI"), and Alpha Natural Resoruces ("ANR"). Stock prices from October 2013 are provided in Table 7.

In addition to having lost over 80% of their stock value, the top three US coal companies are reporting negative returns as discussed below.

Figure 19: Peabody ("BTU") Stock Price October 2007-2012[142]

140 There were numerous media articles on the effect of low natural gas costs in 2012 on the economics of coal. One example can be found at http://www.forbes.com/sites/energysource/2012/05/30/shale-gas-takes-on-coal-to-power-americas-electrical-plants/ .

141 See for example: 1) http://www.washingtonpost.com/business/economy/cost-of-mining-coal-continues-to-climb/2012/10/24/d15666ca-1931-11e2-bd10-5ff056538b7c_story.html, http://grist.org/climate-energy/big-coal-in-big-trouble-as-coal-production-costs-rise/, and http://www.tnr.com/blog/plank/110067/what-was-romney-doing-in-coal-country# See also the report by SNL author Darren Epps on rising production costs for US coal companies issued on April 10, 2013 and summarized here http://ohiocitizen.org/us-coal-producers-scrambling-in-face-of-skyrocketing-production-costs/

142 Stock price chart from Reuters Finance as of October 7, 2012 http://www.reuters.com/finance/stocks/overview?symbol=BTU

Figure 20: Arch Coal Inc. ("ACI") Stock Price October 2007-2012[143]

Figure 21: Alpha Natural Resources ("ANR") Stock Price October 2007-2012[144]

Table 7: Stock Prices Top Three US Coal Companies October 2013 v 2008 Peak

Coal Company	Stock Price Peak 2008[145]	Stock Price October 8, 2013[146]	Percentage Stock Price Change From Peak
Peabody Energy ("BTU")	$88.69	$16.93	-81%
Arch Coal Inc ("ACI")	$77.40	$3.93	-95%
Alpha Natural Resources ("ANR")	$108.73	$5.65	-95%

143 Stock price chart from Reuters Finance as of October 7, 2012 http://www.reuters.com/finance/stocks/chart?symbol=ACI.N

144 Stock price charts from Reuters Finance as of October 7, 2012 http://www.reuters.com/finance/stocks/overview?symbol=ANR

C. Top US Coal Companies Are Reporting Negative Financial Metrics

The rising production costs discussed in Part 3 and the large losses discussed above have led major US coal companies to report negative financial metrics as shown in Table 8 below.

While Republican politicians and others have publicly blamed the coal industry's current financial woes on President Obama's "War on Coal,"[147] they have not generally provided a thoughtful analysis of the geologic difficulties facing US coal production and the impact of rising production costs on profit margins as discussed in Part 3.

Table 8: Key Financial Metrics Top Three US Coal Companies October 8, 2013

As reported by Reuters Finance http://www.reuters.com/finance

Coal Company	Earnings Per Share	Return on Investment	Return on Equity
Peabody Energy ("BTU")	-$2.92	-5.52 %	-15.01 %
Arch Coal Inc ("ACI")	-$1.96	-4.53 %	-14.20 %
Alpha Natural Resources ("ANR")	-$2.13	-4.04 %	-9.60 %

Major US coal companies are reporting large losses and are facing serious financial challenges. It is unclear how long they will be able to remain profitable and what these financial troubles could mean for the production of US coal.

D. Major US Coal Companies Are Facing Large Debts, High Interest Rates

The major US coal companies are carrying large debts and pay interest rates above 5% on much of this debt, with some debt being carried at rates above 9%. Table 9 compares reported market capitalization for the top three coal companies with their debt as reported in 2012 annual 10-K reports.

145 Peak stock prices in 2008 (all on June 1, 2008) determined from http://www.reuters.com/finance/

146 Stock prices for October 8, 2013 at close of trading.

147 See for example, https://www.nytimes.com/2013/07/02/us/politics/gop-sees-opportunity-for-election-gains-in-obamas-climate-change-policy.html?pagewanted=all&_r=0. The coal industry, however, has distanced itself from the "Obama's War on Coal" rhetoric as discussed in http://www.desmogblog.com/2013/07/03/war-coal-doesn-t-exist-says-coal-lobby

Table 9: Market Capitalization and Debt for Top Three US Coal Companies

Company	Market Capitalization October 8, 2013[148]	Debt Reported in 2012 Year-End 10-K Report
Peabody Energy ("BTU")	$4.65 Billion	$6.25 Billion[149]
Arch Coal Inc ("ACI")	$0.87 Billion	$5.08 Billion[150]
Alpha Natural Resources ("ANR")	$1.29 Billion	$3.29 Billion[151]

As can be seen from Table 9 above, the top three US coal companies all have significant indebtedness—and their indebtedness significantly exceeds their market capitalization. In addition, as shown in Table 10 below, significant amounts of debt are coming due in the next several years and this debt was already issued at interest rates above 6%.

Table 10: Debt With Interest Rates Above 6% Facing Top Three US Coal Companies

US Coal Company	Debt Above 6% Coming Due Before 2025[152]	
Peabody Energy ("BTU")[153]	$650 Million due 2016	7.375%
	$1.52 Billion due 2018	6%
	$650 Million due 2020	6.5%
	$1.34 Billion due 2021	6.25%
Arch Coal Inc ("ACI")[154]	$600 million due 2016	8.75%
	$1 Billion due 2019	7%
	$375 Million due 2019	9.875%
	$500 Million due 2020	7.25%
Alpha Natural Resources ("ANR")[155]	$500 Million due 2018	9.75%
	$800 Million due 2019	6%
	$700 Million due 2021	6.25%

148 Market capitalization as shown by Reuters Finance http://www.reuters.com/finance . The relative positions of Arch Coal and Alpha Natural depend on what metric is used. In 2012 Arch sold 134.4 million tons of coal (p. 13, Arch 2012 10-K) while Alpha Natural sold 108.8 million tons of coal (p. 15, Alpha Natural 2012 10-K).

149 Total Peabody indebtedness, page 60 2012 10-K http://www.peabodyenergy.com/content/162/SEC-Filings

150 Total Arch Coal indebtedness, page 70, 2012 10-K, http://investor.archcoal.com/phoenix.zhtml?c=107109&p=irol-reportsAnnual

151 Total Alpha Natural Resources indebtedness, page 77, 2012 10-K http://alnr.client.shareholder.com/sec.cfm

152 For full list of coal company debt, see 2012 10-K's identified in footnotes for Table 9.

153 Peabody debt, page 60, 2012 10-K http://www.peabodyenergy.com/content/162/SEC-Filings

154 Arch Coal debts, page 70, 2012 10-K, http://investor.archcoal.com/phoenix.zhtml?c=107109&p=irol-reportsAnnual

155 Alpha Natural Resources debts, page 77, 2012 10-K http://alnr.client.shareholder.com/sec.cfm

E. Patriot Coal is Bankrupt; Other Coal Companies Are On Bankruptcy Watch

As described above, US coal companies have faced a variety of financial challenges over the first decade of the 21st century, including:

- Increasing production costs as the coal becomes more difficult and expensive to mine
- Shrinking profit margins as sales prices rise more slowly than production costs
- Reduced demand due to environmental concerns and regulations
- Increased competition from other ways to produce electricity including natural gas and declining-cost renewable energy including wind and solar.

The result of these challenges is described above with coal companies reporting:

- Large quarterly and annual losses
- Negative earnings per share and return on investment and equity
- Plummeting stock prices
- Large debt looming with already high interest rates.

As a result of the financial challenges discussed above, Patriot Coal filed for bankruptcy in mid-2012 and other major US coal companies are facing financial challenges that could lead to bankruptcy as described below.

1. Patriot Coal Declared Bankruptcy in July 2012

In July 2012, Patriot Coal, a significant producer of Appalachian coal,[156] filed for bankruptcy.[157] Patriot was formed in 2007 as a spin-off from Peabody coal. Then in 2008, Patriot coal acquired Magnum Coal which had been spun off from Arch Coal Inc. in 2005.[158] United Mine Workers of America has argued that Patriot was "designed to fail,"[159] while a Peabody Energy spokesperson claims that Patriot Coal was "designed to succeed."[160] The overall decline in production in Appalachian coal mines has been detailed in an extensive report by Downstream Strategies[161] and the depletion of Appalachian coal reserves has been noted by long-time industry analysts.[162]

Whether Patriot was designed to succeed or fail is now moot, as Patriot Coal has indeed failed and has filed for reorganization under Chapter 11 bankruptcy rules and Patriot, Peabody and the United Mine Workers are battling over retiree benefits in bankruptcy courts. A District Court decision has allowed Patriot to eliminate approximately $1.6 billion in retiree health liabilities and replace them with a "Voluntary Employee Beneficiary Association" (VEBA) with[163] a much lower level of potential funding.[164] This has led to widespread and repeated protests from coal miners and their

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156 In 2011, the Energy Information Administration listed Patriot as the 11th largest US coal company with over 27 million tons of coal production. See http://www.eia.gov/coal/annual/pdf/acr.pdf, Table 10, page 15.

157 See for example http://www.forbes.com/sites/afontevecchia/2012/07/09/patriot-coal-files-for-bankruptcy-secures-802m-in-financing/

158 For a history of Patriot Coal see http://www.patriotcoal.com/index.php?view=our-history&p=79&s=83

159 See for example, the "Rader Report" which claims that Patriot got more health care liabilities than assets http://www.fairnessatpatriot.org/wp-content/uploads/2013/02/RaderReportFinal.pdf and the comments of UMWA President Cecil Roberts at http://www.stltoday.com/news/opinion/columns/how-peabody-meets-its-commitments/article_e17e2f2c-ebe4-5276-9bd2-a27b6ce96092.html and http://www.theatlantic.com/business/archive/2013/06/this-is-capitalism-now-how-a-coal-company-bilked-20-000-workers-out-of-health-benefits/276438/

160 See the claims of Peabody spokesperson Vic Svec at http://www.stltoday.com/news/opinion/columns/umwa-misleads-when-it-tries-to-rewrite-history-of-patriot/article_c6b6ccbb-1491-5174-8911-746d9bc0aae8.html

161 See "The Continuing Decline in Demand for Central Appalachian Coal: Market and Regulatory Influences" by McIlmoil and all (2013) found at http://www.downstreamstrategies.com/documents/reports_publication/the-continuing-decline-in-demand-for-capp-coal.pdf

162 See http://www.statejournal.com/story/19624223/expert-reserve-depletion-not-war-on-coal-is-wvs-problem

163 Descriptions of the Patriot protests can be found at http://www.fairnessatpatriot.org/

164 For a description of the District Court decision on the treatment of Patriot's retiree health liabilities, see http://online.wsj.com/article/SB10001424127887324412604578513572460160236.html The full decision can be found at http://www.fairnessatpatriot.org/wp-content/uploads/2012/10/Patriot-Judge-Decision-5_29_13-Doc-40811.pdf

allies.[165] The UMWA has filed an appeal of the District Court decision[166] and the Bankruptcy Appellate Court ruled that Peabody would be responsible for some of the benefits for the retired employees.[167] Peabody has, however, continued to argue that it has no obligation for retiree benefits.[168]

2. #2 Arch Coal Facing Large Debts, Sold Off Its Most Profitable Mines

As detailed in Table 10 above, Arch Coal Inc. is facing large debts that are coming due in the next several years with large debts already carrying interest rates from 7 to 9.875%. One industry analyst has suggested that Arch Coal is in the "land of the walking dead,"[169] and may face bankruptcy by mid-decade due to depressed cash flows and large interest payments.[170]

With limited liquidity, Arch announced in late June 2013 that it would sell off three bituminous mines in Utah for $435 million in cash.[171] Arch's western bituminous mines had the highest operating margins of any of the Company's mines in 2012,[172] with 2012 operating margins above $8 per ton for the bituminous mines (including the three Utah mines) while operating margins in Appalachia and the Powder River Basin were less than $1 per ton.

While the sale of the Utah mines will provide Arch Coal with some short term liquidity, the sale of three of its most profitable mines, appears to be similar to eating a community's supply of "seed corn" to avoid starvation in the near term while undermining chances for long term survival. One analyst estimated that by selling off the three Utah mines Arch would be forgoing approximately one-fifth of its annual earnings.[173]

3. #3—Alpha Natural Resources Is On Bankruptcy Watch and Borrowing at High Interest to Pay off Lower Interest Debt

As shown in Tables 8 through 10 above, the third largest US producer of coal, Alpha Natural Resources is facing serious financial challenges including reporting significant losses, high levels of debt and negative returns on investment.

In October 2012, GMI Ratings[174] put Alpha Natural Resources on high alert for bankruptcy, noting that ANR has a "higher chance of financial distress than 98% of comparable companies rated by GMI Ratings" and "Alpha Natural remains entangled in legal issues and struggling to raise capital as profitability plummets and its long-term sustainability remains shrouded in doubt ."[175]

One of the issues noted by GMI was the issuance of bonds by Alpha Natural at 9.75% to replace earlier bonds at 3.25%.[176]

Alpha Natural Resource's long term debt rose dramatically in mid-2011 from less than $1 billion to over $3 billion,[177] corresponding to the time frame when Alpha Natural Resources acquired Massey Coal in mid-2011 for approximately $5.8 billion.[178] In May 2013, Alpha Natural Resources modified its

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165 The protests against Peabody and Patriot are described at http://www.fairnessatpatriot.org/ .

166 The UMWA appeal can be found at http://www.fairnessatpatriot.org/wp-content/uploads/2012/10/DE-4117.pdf

167 See http://www.reuters.com/article/2013/08/21/peabody-retirees-idUSL2N0GM1LM20130821?symbol=BTU

168 See http://www.reuters.com/article/2013/09/13/us-patriotcoal-labor-peabody-idUSBRE98C10X20130913?symbol=BTU

169 See http://seekingalpha.com/article/841941-arch-coal-walking-dead

170 For a discussion of possible bankruptcy by Arch Coal, see http://seekingalpha.com/article/1539552-arch-coal-may-face-bankruptcy-by-mid-decade

171 See http://news.archcoal.com/phoenix.zhtml?c=107109&p=irol-newsArticle&ID=1833707&highlight=

172 See pages 2-4 in Arch Coal Inc 2012 Fourth Quarter and Full Year report available from http://investor.archcoal.com/phoenix.zhtml?c=107109&p=quarterlyearnings

173 See http://www.bloomberg.com/news/2013-06-28/arch-coal-to-sell-utah-mines-for-435-million.html

174 See http://www3.gmiratings.com/home/

175 See http://www3.gmiratings.com/home/2012/10/alpha-natural-resources-inc-poses-imminent-danger-to-shareholders/

176 See also http://www.reuters.com/article/2012/10/26/idUS165543+26-Oct-2012+PRN20121026

177 See http://ycharts.com/companies/ANR/long_term_debt

178 See http://alnr.client.shareholder.com/releasedetail.cfm?ReleaseID=546291 and http://www.forbes.com/sites/oshadavidson/2011/06/01/alpha-and-massey-coal-companies-to-merge/.

credit agreement by obtaining a $625 million "Term Loan B facility" in order to pay off a $525 million "Term Loan A facility."[179] Term Loan B facilities involve "high yield" or sub-investment (i.e. junk bond) rates.[180] In effect, what Alpha Natural Resources has done is to take out a high-cost loan to pay off a low-cost loan. While no one knows what will happen to future coal markets, this appears to be a high-stakes gamble with potential for serious future financial consequences.

4. Other Coal Companies Are Facing Serious Financial Issues

Examples of other coal companies that are either getting out of the coal business or facing serious financial issues (including their 2011 US rank by sales)[181] include:

- Cloud Peak[182] (#4 in 2011)[183] appears to be financially stronger than Arch or Alpha, but productions costs are generally rising faster than sales price and coal production volumes, net income and earnings are generally dropping.[184] Recently Cloud Peak failed to submit a bid for the Maysdorf II federal coal "lease" in part because, given the "projected costs of mining the remaining coal," Cloud Peak was "unable to construct an economic bid for this tract at this time."[185] In addition, Cloud Peak has announced that it will likely cut production from the Cordero Rojo mine in Wyoming (third largest US coal mine) by about 25% in 2015, in part because it is unwilling to invest the additional capital that is needed to mine coal that is buried more deeply.[186]
- Consol Energy[187] (#5 in 2011) is reporting declining coal production, declining profit margins and in 2013 Q2 reported a net loss of $13 million.[188]
- Energy Future Holdings (#8 in 2011) is facing over $37.8 billion in debt and preparing to file for bankruptcy.[189] The famous investor Warren Buffett could lose as much as $2 billion that he invested in Energy Future Holdings.[190]
- BHP Billiton (#14 in 2011) appears to be backing out of the coal business. It has all but ruled out new coal projects and says it is selling assets because of a weak coal price outlook.[191]
- Walter Energy (#15 in 2011) reissued its financing at higher rates in July 2013 and cut its dividend to 1 cent down from 12.5 cents/share.[192]

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179 See http://seekingalpha.com/news-article/662368 1-alpha-natural-resources-completes-changes-to-credit-facility?source=email_rt_mc_press_0

180 See http://www.creditflux.com/Glossary/Term-loan-B/

181 For 2011 rank of coal companies by production, see Table 10 in the EIA Annual Coal Report available from http://www.eia.gov/coal/annual/

182 Cloud Peak owns two mines in Wyoming (the Cordero Rojo and Antelope mines) and one in Montana (the Spring Creek mine). Total coal production is about 90 million tons per year.

183 Cloud Peak owns two mines in Wyoming (Cordero Rojo and Antelope) and one in Montana (Spring Creek). Cloud Peak is part owner of the Decker mine in Montana which is currently under a management dispute involving Ambre Energy. See http://www.coalzoom.com/article.cfm?articleid=2038

184 See http://cloudpeakenergy.com/investor-relations/press-releases/

185 See http://www.businesswire.com/news/home/20130821005895/en/Cloud-Peak-Energy-Confirms-Bid-Maysdorf-II

186 See http://seekingalpha.com/article/1692022-cloud-peak-energys-ceo-presents-at-barclays-capital-ceo-energy-power-conference-transcript?page=4 and http://www.coalage.com/index.php/features/2973-prb-operators-reduce-production-to-match-market-demand.html

187 Consol Energy produces both metallurgical and thermal coal, primarily from the Northern Appalachian region and also produces natural gas from various locations in the US and around the world. See http://www.consolenergy.com/about-us.aspx

188 See http://phx.corporate-ir.net/phoenix.zhtml?c=66439&p=irol-newsArticle&ID=1840967&highlight=

189 See http://dealbook.nytimes.com/2013/04/15/energy-future-holdings-offers-bankruptcy-plan/?_r=0 and http://online.wsj.com/article/SB10001424052702304171804579124113257930636.html

190 See http://www.bloomberg.com/news/2012-02-27/buffett-says-energy-future-bond-bet-at-risk-of-being-wiped-out.html

191 See http://www.abc.net.au/news/2013-05-29/bhp-selling-assets-on-muted-coal-price-outlook/4719826m

192 See http://investorrelations.walterenergy.com/phoenix.zhtml?c=71978&p=irol-newsArticle&ID=1840276&highlight= and http://www.reuters.com/article/2013/07/24/us-walterenergy-dividend-idUSBRE96N0SB20130724

- James River Coal (#16 in 2011) has reported losses in last seven quarters, has a net debt of over $450 million, has idled several mines and has exchanged notes that were costing 3-4% for notes that will cost 10 percent.[193] One analyst has conservatively predicted a 75% chance of bankruptcy for James River Coal by the end of 2014.[194]
- Ambre Energy, an Australian company attempting to gain full control of the Decker mine in Montana, has been unable to obtain the $70 million needed to close the deal.[195]

No one can predict the financial future of US coal mining companies and there are some analysts who believe a rise in coal sales prices will lead to a rebound in the coal industry,[196] but many other analysts are questioning whether the US coal industry can recover significantly from its current financial woes.[197]

Only time will tell what the future holds for the US coal industry, but one thing that is clear is that the coal that remains in the ground in the United States will be more difficult and very likely more expensive to produce than the coal that was mined and which powered the United States economy in the 20th century. What isn't known is how long US coal companies, many of whom are already facing serious financial challenges, will be able to mine coal at a profit. If coal can't be mined at a profit, it is not likely that much of it will be mined by for-profit companies.

193 See http://www.bloomberg.com/news/2013-05-17/james-river-coal-rises-after-announcing-convertible-note-swap.html and http://seekingalpha.com/article/1679192-james-river-coal-valuation-ignores-risk-from-lack-of-thermal-coal-contracts?source=google_news

194 See http://seekingalpha.com/article/1679192-james-river-coal-valuation-ignores-risk-from-lack-of-thermal-coal-contracts?source=google_news

195 See http://tdn.com/news/state-and-regional/washington/ambre-energy-s-montana-coal-mine-deal-beset-by-financing/article_f94ae866-e5c5-11e2-80e5-0019bb2963f4.html and http://www.oregonlive.com/environment/index.ssf/2013/05/deal_on_montana_coal_mine_stal.html

196 See for example, http://seekingalpha.com/article/1533542-peabody-energy-commodity-contrarian-investing-101?source=email_rt_article_readmore and http://seekingalpha.com/article/1513742-depressed-valuations-for-alpha-natural-resources-offers-an-attractive-opportunity?source=email_rt_article_readmore

197 See for example, http://www.fool.com/investing/general/2013/06/15/coal-on-the-wrong-side-of-energys-future.aspx and http://money.msn.com/top-stocks/blog--coal-is-first-casualty-of-energy-abundance and http://about.bnef.com/blog/caldecott-will-old-king-coal-continue-to-be-a-merry-old-soul/

PART 6:
How Much Longer for the US Coal Industry?

A. Serious Disruption for the US Coal Industry Possible in the Next 5-10 Years

The question is now beginning to be asked, "How much longer will the US coal industry be producing significant quantities of reasonably priced coal?" The only honest answer is that no one knows. The future is always unknown and the future cost and production trajectories for all fossil fuels will result from the interplay of complex forces of supply and demand. Nonetheless, there is now a strong set of reasons to believe that the planning horizon for moving the United States largely past using coal for electricity production is something significantly less than 20 years—and could be less than 10 years—for all of the geological and financial reasons discussed in this report, and independent of discussions about future controls on carbon dioxide and other pollutants.

In general, it is likely that production costs will keep rising, productivity will decline and profit margins for the coal industry will thin as we move forward. It is unknown if and how the coal companies will be able to make the large debt payments that are coming due in 2016 and beyond. Will US coal companies be able to refinance the debt that has already been issued at rates above 6%? No one can know for sure, but it seems questionable at best, that investors will be willing to bet billions of dollars on an industry that is likely becoming obsolete.

Moving forward, renewable technologies for generating electricity are likely to become increasingly price competitive and concerns about climate change, air pollution, coal ash, toxic emissions, mining destruction and water use are likely to keep the pressure on decision makers to move beyond the use of fossil fuels to generate the majority of electricity for the United States.

It is axiomatic that no one can predict the future. Moreover, the future of the US coal industry will depend on the interplay of complex forces of supply and demand. Nonetheless, there is now a strong set of reasons to believe that the planning horizon for moving the United States largely past using coal for electricity production is something significantly less than 20 years—and could be less than 10 years—for all of the geological and financial reasons discussed in this report.

With rising production costs, serious debt challenges and declining-cost renewable energy technologies, it is unclear how much more US coal can be mined at a profit. If coal can't be mined for profit, it is unclear how much coal will be mined by for-profit companies. This means that the United States will very likely need to repower with other technologies. Many have recognized the need to repower the United States as an opportunity to drive innovation and economic development while building a 21st century, lower-carbon and more flexible, resilient and distributed electric grid.[198]

B. Future Variables that Could Affect the Long Term Outlook for the US Coal Industry

Given that no one can predict the future, this section provides brief discussions of variables that are often cited as possibly leading to changes in the outlook for the US coal industry.

1) Rising Coal Prices

While rising prices for coal could help ease the financial challenges facing the US coal industry, it is not clear how much they will help and for how long. To be helpful, prices would have to rise significantly faster than production costs in order to increase profit margins.[199] This means prices would likely have to rise at a rate greater than 7-8% per year. At this rate, the cost of coal would double in a decade or less and it is not clear how long utilities and their customers will be willing to pay these higher prices for coal, particularly given concerns about climate change, emissions of toxic metals and other pollutants, mining damage and water use as well as the availability of lower-cost renewable energy technologies.[200]

Rising prices for coal could help the coal industry in the short term, but in the long term are likely to lead to futher reductions in coal use as utilities and their customers opt for cost-competitive options, including declining-cost renewable energy technologies.

2) Rising Natural Gas Prices

While coal industry supporters have argued that rising natural gas prices will benefit coal companies, it is unclear how much help this will be—particularly in the long run. Costs to produce coal are rising, so once again, it is likely to be a complex relationship between rising natural gas costs and rising coal costs. In addition, as the price of coal and natural gas both increase, utilities and their customers will be interested in shifting to cost-competitive renewable energy options.

3) Exports of Coal

Much has been written in recent years about the benefits to the US coal industry from the potential to export coal to other continents including Europe, South America and Asia.[201] In recent months, it has become apparent that any coal exported from the United States would have to compete favorably on price terms with coal from other countries in the global coal market. Given falling coal prices in China and cheaper supply from other locations including Australia and Indonesia, it is not clear that coal exports will be the "promised land"[202] that the

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198 See for example, the National Renewable Energy Laboratory Renewable Energy Future study at http://www.nrel.gov/analysis/re_futures/ See also the Edison Electric Institute study at www.eei.org/ourissues/finance/Documents/disruptivechallenges.pdf and NRG's proposal at http://www.bloomberg.com/news/print/2013-03-24/nrg-skirts-utilities-taking-solar-panels-to-u-s-rooftop.html

199 For a detailed discussion of increases in coal prices that are needed to keep James River Coal Company (JRCC) from bankruptcy, see http://seekingalpha.com/article/1679192-james-river-coal-valuation-ignores-risk-from-lack-of-thermal-coal-contracts?source=google_news

200 See for example, Aleklett 2009, page 25 "Historical trends in American coal production and a possible future outlook" Mikael Höök, Kjell Aleklett, International Journal of Coal Geology 78, 201 (2009) available from http://www.sciencedirect.com/science/article/pii/S0166516209000317

201 For examples of the benefits claimed for the US coal industry from the potential to export coal, see http://www.peabodyenergy.com/mm/files/Investors/IR%20Presentations/2%20Jacob%20Williams%20Coal%20Markets.pdf and http://www.nma.org/index.php/press-releases/press-releases-2013/901-nma-tells-congress-coal-exports-benefit-u-s-and-the-world

202 See http://daily.sightline.org/2013/08/06/the-coal-export-bubble/

US coal industry has hoped for.[203] A recent Goldman Sachs report summarized the situation as follows:

> But overseas demand for thermal coal — the kind used in power plants — has been overestimated. New investments in thermal coal infrastructure, unless they come online **quickly**, will miss a rapidly closing window for profitability. In coming years, there won't be enough demand growth to justify such investments.[204]

Even if coal exports were to become a significant profit center for US coal companies, which now looks doubtful, it appears that global price pressure would also increase coal prices for US utilities and increase pressure to move the US away from coal.

4) Montana

According to EIA Table 15 in the Annual Coal Report, Montana is the state with the highest levels of "Estimated Recoverable Reserves" with over 74 billion tons, while Wyoming and Illinois follow with approximately 37 billion tons of Estimated Recoverable Reserves each.[205]

Despite EIA reporting a high level of coal "reserves" for Montana, it is questionable whether these coal deposits will ever be mined in large quantities. As shown previously in Figure 13, coal production in Montana appears to have peaked in 2008 at about 44.8 million tons and has fallen off since then. In addition, there are concerns about high sodium content,[206] environmental concerns, severance tax rates and lack of railroad competition.[207]

For Montana coal production to match that of Wyoming, production would have to increase about 10 fold,[208] but the USGS has pointed out that only a small fraction of Montana coal is likely to be profitable[209] and it is not clear that Montana residents want to trade sustainable agricultural operations for a "one-time harvest"[210] of coal.[211]

5) Alaska

Coal production from Alaska is presently only about 2 million tons compared to total US coal production of over 1 billion tons.[212] To supply current coal uses, coal mining in Alaska would have to increase by about 500 times. This seems unlikely. In addition, coal from Alaska would need to be transported to the lower 48 and currently the needed transportation infrastructure is not available. Adding this transportation infrastructure would increase the cost of delivered coal and likely make it of questionable economic competitiveness for coal plants in the lower 48 states.

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203 For examples of the complexities of the Asian and global coal markets see http://www.coalguru.com/australia/coal_mines_can_039_t_compete_report/9792, http://seekingalpha.com/article/1616812-cloud-peak-energy-hunkers-down-waits-for-exports?source=email_rt_article_readmore, http://news.xinhuanet.com/english/business/2013-08/06/c_132607502.htm, http://in.reuters.com/article/2013/08/14/column-russell-coal-australia-idINL4N0GF0TY20130814

204 As quoted in http://grist.org/climate-energy/goldman-sachs-says-coal-export-terminals-are-a-bad-investment/

205 See http://www.eia.gov/coal/annual/pdf/table15.pdf

206 See pages 15-16 in http://pubs.usgs.gov/of/2012/1113/OF12-1113.pdf

207 See Aleklett, page 25 in "Historical trends in American coal production and a possible future outlook" Mikael Höök, Kjell Aleklett, published in International Journal of Coal Geology 78, 201 (2009) available from http://www.sciencedirect.com/science/article/pii/S0166516209000317

208 Montana coal production is currently less than 40 million tons while that in Wyoming is over 400 million tons. See Table 1 in the EIA Annual Coal Report at http://www.eia.gov/coal/annual/pdf/table1.pdf

209 See page 1 in http://pubs.usgs.gov/of/2012/1113/OF12-1113.pdf

210 See Aleklett, page 9 (referring to North Dakota) in "Historical trends in American coal production and a possible future outlook" Mikael Höök, Kjell Aleklett, published in International Journal of Coal Geology 78, 201 (2009) available from http://www.sciencedirect.com/science/article/pii/S0166516209000317

211 See for example, "Montana Coal Mining Plan Draws Opposition," at http://usatoday30.usatoday.com/money/industries/energy/story/ 2012-08-15/montana-mining-plan/57143158/1 and http://blog.nwf.org/2013/04/why-the-otter-creek-coal-mine-will-never-be-built/ and http://www.columbian.com/news/2013/may/05/rising-coal-exports-asia-stir-fight-northwest/?print

212 See the 2011 Annual Coal Report, Table 1 available at http://www.eia.gov/coal/annual/pdf/table1.pdf

6) Underground Coal Gasification

Underground coal gasification may provide a new technique for producing natural gas at coal mines,[213] but it is unclear whether this can be done economically. Moreover, producing natural gas at coal mines will not provide more coal for US coal plants in distant cities. Some coal plants can burn natural gas without modification, but they are not typically very efficient at converting the natural gas into electricity.[214]

7) Improved Coal Mining Efficiency or Technology

The impact of improved efficiency or technology on mining coal is difficult to predict, but in recent years there have not been any significant breakthroughs and in general coal mining productivity is going down as discussed in Part 3. Monitoring changes (positive and negative) in miner productivity is part of the complex set of variables that need to be analyzed to determine how many of the coal resources of the United States are likely to be mined profitably and the proper time frame for repowering the country.

8) Imports

It is unclear what potential, if any, there is to import significant volumes of coal from other countries. Many Asian countries are already experiencing significant coal supply constraints and it isn't clear that there are significant volumes available for import into the United States. In addition, the cost of imported coal is likely to be substantially more than coal currently supplied by US coal mines.

From a review of the variables that could improve the long term outlook of the US coal industry, it does not appear that any of these variables are likely to have a significant impact. Only time will tell, but it would be prudent for political and economic leaders to consider future scenarios that require the US to move beyond coal in a time frame that is significantly shorter than 20 years.

213 See http://www.ucgassociation.org/

214 Each coal plant is unique, but a coal plant converted to natural gas may be less efficient and will typically have a relatively high "heat rate" meaning it will take more energy in the form of BTUs to create a MWh of electricity.

CONCLUSION

The US is very likely rapidly approaching the end of economically recoverable coal. The reporting by the US Energy Information Administration of over 250 billion tons of "Estimated Recoverable Reserves" of coal has acted like a faulty fuel gauge on US coal supplies. Most of the coal in the US is very likely buried too deeply to be mined at a profit. What the EIA has reported as coal "reserves," are better described as coal "resources" that are in the ground but are unlikely to be mined at a profit.

Decision makers at all levels should begin planning for the possible necessity of moving the US beyond coal in something significantly less than 20 years. Independent of decisions about future environmental regulations, utilities, utility regulators and investors should avoid making investments in aging coal infrastructure on coal cost and supply issues alone.

It is very likely that the United States will reach the end of its economically recoverable coal supplies well before "200 years." Given the financial difficulties already being experienced by US coal companies and the increasing difficulty and expense of mining the remaining coal, US coal production could become seriously hampered in the next decade.

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